Power and The Engineer

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THERE is a right and a wrong way to do everything. This applies even to reading your POWER. In fact, there are numerous *wrong* ways in which this can be done.

What is one man's meat is another man's poison. In a like manner that which is the best way for one man to read his technical magazine may be altogether wrong for another.

No hard and fast rules can be laid down for all to follow.

One general suggestion can be offered, however: *Get* what you go after.

A technical periodical which is rightly balanced contains in every issue something for the men of each level of that branch of engineering to which the paper is devoted.

Now, most men have not the time to read from 40 to 45 pages each week and *get* all that they contain.

By "get" we mean read so carefully that all of the facts will become fixed in his memory.

It thus becomes necessary to make a careful selection of the articles printed in each number. The chief engineer of some big electric railway or lighting system would find it unprofitable to read articles such as "Device for Inserting a Valve Stem" and "A Homemade Planimeter" to the neglect of some of more importance to him. In the first place, he may never need to use the information they contain; in the second, he can use the time to better advantage by devoting it to articles dealing with subjects more closely connected with his position.

By the same token, it is unprofitable for the man in charge of a 100-horsepower plant to pore over articles dealing with the construction or design of some big central station.

By this we do not mean that he should not read any but the articles which vitally concern him. On the contrary, the more he reads the better, providing, of course, that he does not do the extra reading at the expense of more important things.

Read your scientific paper in a *scientific* manner. Its chief purpose is to help and instruct.

Get the help and instruction first. By so doing you avoid the possibility of losing out through lack of time to read what you should read for your own improvement and profit.

There are some subjects which are of importance to you. When an article on one of them appears, go after *all* that it contains. Don't glance through it and then turn the page, with the remark, "That's a good article. I'll read that carefully,—tomorrow."

Tomorrow never comes, no matter how good your intentions are.

If you are wise, you will "anchor" right at that article and "dredge" for all that there is in it. You will check the facts as far as you are able.

By so doing you will not only establish their reliability, but will also fix them more firmly in your mind.

After you have "*got*" the articles designed for you, if you have any time to spare, pass on to the pages not so closely related to your particular work.

But *get yours first*, and get it *right*.

Economical Fire Room Methods

By F. R. Low

In the plant under discussion it is realized that the boiler room is the place to save fuel. Return tubular boilers are hand fired by intelligent men at regular intervals with uniform quantities of coal. Fans furnish the draft and an economizer reduces the temperature of the escaping gases to 200 degrees and raises the temperature of the hotwell water from 105 to 185 degrees. Careful firing gives a high percentage of CO_2, and but little excess air. Some remarkable results are obtained in the plant.

I had the privilege and pleasure of spending a day recently with George H. Diman, of Lawrence, Mass. We had made the rounds of the power plants of the American Woolen Company, which are run under Mr. Diman's direction, and wound up at the Wood mill, which is Mr. Diman's particular favorite, being his own creation, erected under his direction and from his own designs. "Come down to the boiler room," he said, "I want to show you my Hibernian Automatic Stokers."

"The Hibernian stoker," I said, "Never heard of it."

"You can't beat them," he said, as he pointed to a line of firemen operating the boilers by hand, and drew up some chairs where we could watch operations.

The boiler house is light and roomy, behind the boilers as well as in front, and spick-and-span all over. It contains forty-two 72-inch horizontal return-tubular boilers with 20-foot tubes, and everything goes on with the regularity of clock work.

"How do you keep it so clean," I asked.

"By never letting it get dirty," was the laconic reply.

The captain introduced me to the head fireman and told him to bring him "some of those records." He produced a pack of recording-temperature gage charts and Mr. Diman passed them to me with the question, "Did you ever see a boiler plant with a lower stack temperature than that?"

I looked the records over. Fig. 1 is an average sample. The inner diagram shows the variation of the temperature at which the gases go to the stack.

It hangs close to 200 degrees.

The larger diagram shows the temperature of the gases as they leave the boilers—never up to 500 degrees, and part of the time less than 400.

Economizers reduce them to the low final temperature, and were raising the feed-water temperature on the day of my visit from that of the hotwell, about 105, to 185 degrees. Four 15-foot Sturtevant fans on the cool side of the economizer supplied the draft.

I was obliged to own that I had never seen gases sent to the stack so cool before, and asked, "How much excess air is there in them?"

"Look at that gas analysis I gave you," advised the captain.

I pulled it out, and it was as follows:

Lawrence, Mass, April 29, 1910.

G. H. Diman, Esq., Consulting Engineer,

WOOD WORSTED MILLS.

Dear Sir:

Record of gas analyses made April 29, 1910. Samples taken from uptake just back of the front doors:

Boiler No. 6.

Time.	Carbon Dioxide.	Oxygen.	Carbon Monoxide.
8:45 a.m.....	14.1%	3.5%	0.0%
8:55 a.m.....	14.4%	4.6%	0.0%

Boiler No. 9.

9:05 a m.....	15.4%	0.9%	0.5%

Boiler No. 15.

9:20 a.m.....	15.0%	**3.6%**	0.0%
9:30 a.m.....	12.8%	**6.7%**	0.0%

Boiler No. 18.

9:40 a.m.....	12.7%	6.4%	0.0%
Average....	14.1%	4.5%	0.1%

WOOD WORSTED MILLS.

Dear Sir:

Record of gas analyses made May 13, 1910. Samples from boilers No. 33 and No. 35 were taken from the center of the roof of boilers. Other samples were taken from the uptake, as previously.

Samples from boiler No. 33 show what value the flue-gas analyses may have in locating trouble with the fire.

It was found by the man in charge after the 9:30 a.m. sample was taken, that the fire had burned a hole in the side. This was remedied, and the 9:40 sample shows a much better result:

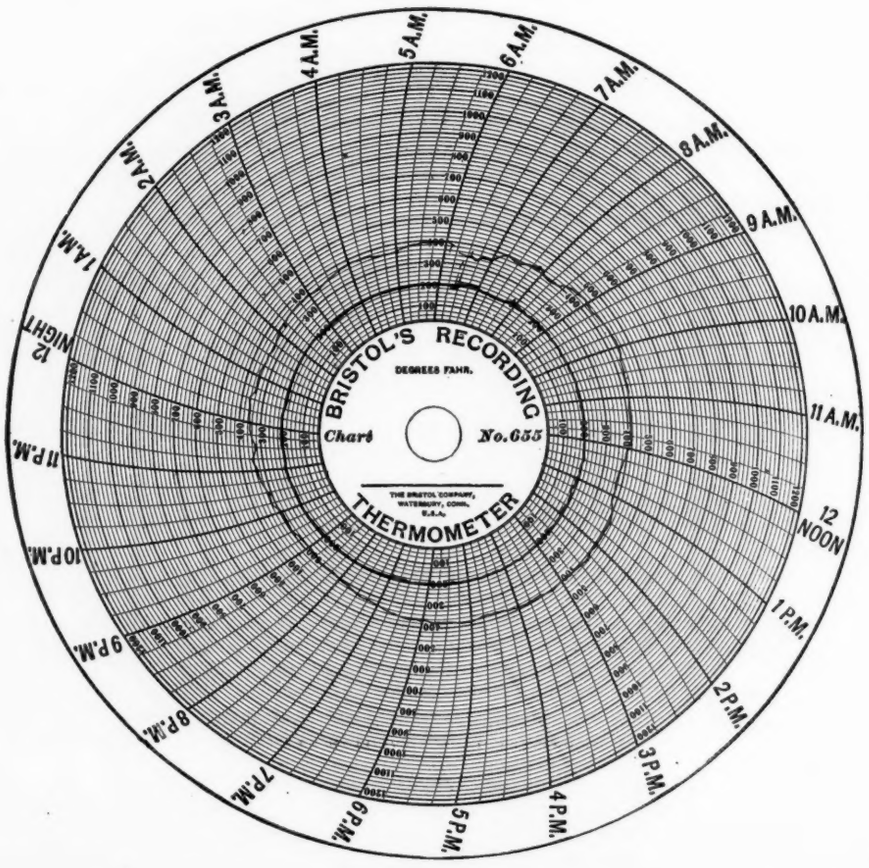


Fig. 1. Typical Record of Uptake and Stack Temperatures

BOILER No. 33.

Time.	Carbon Dioxide.	Oxygen.	Carbon Monoxide.
8:45 a.m.....	13.1%	4.8%	0.0%
8:55 a.m.....	11.8%	6.6%	0.0%
9:05 a.m.....	11.6%	7.1%	0.0%
9:15 a.m.....	10.8%	7.7%	0.0%
9:30 a.m.....	8.4%	11.5%	0.0%
9:40 a.m.....	13.7%	4.8%	0.3%

BOILER No. 35.

9:50 a.m.....	13.5%	6.0%	0.0%

BOILER No. 28.

Time.	Carbon Dioxide.	Oxygen.	Carbon Monoxide.
10:05 a.m.....	13.3%	5.2%	0.1%

BOILER No. 29.

10:15 a.m.....	14.0%	5.3%	0.2%

BOILER No. 25.

10:25 a.m.....	11.8%	7.5%	0.1%
10:35 a.m.....	10.4%	9.7%	0.0%
Average....	12.0%	6.9%	0.1%

Lawrence, Mass., May 13, 1910.
G. H. Diman, Esq., Consulting Engineer,
Yours truly,
P. F. RIPLING,
(P. F. R.) Chemist.

"We have our own chemist come in and make these analyses every week. He comes unexpectedly, picks his own boilers and fires, and his reports will all run about like that. Not much free air when you are getting that kind of analysis, is there?"

There certainly could not be, and really such excess air as there was represented a considerably less loss at this low temperature than at the usual temperature of around 500 degrees. If, as Mr. Diman pointed out, he cooled the gases down to the temperature at which the air came in, it would not make any difference how much excess air there was, for none of it would go away hotter than it came, and so would not carry out any heat units.

The boilers are hand fired on ordinary Foster flat shaking grates. "How do you manage your fires," I asked, "to keep up any such percentage of CO_2 as that?"

"Watch them," he said, "get out your watch and count the scoopfuls."

The plant is divided, so far as organization and operation are concerned, into four groups of ten boilers each. Each group has twenty fire doors and four stokers, giving five fire doors to a man. The man at the near end of the group would fire the first, third and fifth doors. The second man would take it up and fire the seventh and ninth; then the next man, and so on. Each man put on just nine scoopfuls of coal, no more and no less. When the first man had finished coaling door No. 3 he took his hoe and trimmed Nos. 2 and 4, then he went and sat down. Each fireman has a stout, comfortable chair, and it is for his especial use. Fireman No. 2 was soon sitting beside him, having fired his two doors and trimmed his three. After an interval of eight or ten minutes from the time he fired No. 1 door, fireman No. 1 sees fireman No. 4 finish his turn, gets up, coals furnaces Nos. 2 and 4, trims Nos. 1, 3 and 5, and sits down again. Fireman No. 2 commences to throw coal into No. 6 as soon as fireman No. 1 closes the door of No. 4, and as soon as he has fired 6, 8 and 10, and trimmed 7 and 9, he sits down by his partner.

And so it goes on like clockwork. Nobody has to be told when it is his turn, there is no bossing, nagging, nor bawling, the men work easily and systematically, there are never more than two doors open in the group at a time, that into which the man is shoveling and that of the furnace which is being trimmed. The firing of alternate doors at considerable intervals insures that one side of each furnace shall be full of seething, white-hot, well coked coal to burn the volatiles from the fresh fuel fired to the other side, and the fire is carried some 14 inches in thickness all over the grates, giving no chance for air to get in without losing its oxygen to the white-hot carbon. If the load is light and coal is not being burned so fast but that the fires thicken up under this treatment above 16 inches or so, the number of scoopfuls per firing is reduced; but they can get around fast enough, so that nine scoopfuls at a time will supply all the coal the boilers will use at the greatest rate that they are ever driven.

"What about slicing?" I asked.

"Only when the whistle blows," was the reply.

"And the whistle blows——?"

"When the pressure falls 15 pounds," said the captain, smiling as he saw my puzzled look.

FIG. 2. ONE SIDE OF THE WOOD MILL BOILER ROOM

"There is another fallacy," he explained, "that we have all been trying to live up to. We've all been trying and educating our men to try to keep a perfectly even boiler pressure. We put on a damper regulator, and it held the steam pressure within a pound, and the recording-pressure gage made a straight line, and we thought it was great. Well how did it do it? When the pressure got a little bit too high the damper went shut. You cut off your air supply and your furnaces went to making carbon monoxide; 4450 B.t.u. to the pound of carbon, instead of 14,500, sending off the same kind of gas that they use to run gas engines up the stack, instead of burning it in the furnace. Figure out some time how little you lose by dropping your steam pressure from 160 to 145, and how much you lose by dropping your percentage of CO_2 from 14 down to 8 by imperfect combustion."

"Now instead of monkeying with my dampers to try to keep an absolutely straight steam pressure, I try to keep the air supply so that it will burn the coal. The steam pressure can vary the speed of the fans so that the draft over the fire runs from about 0.3 of an inch when the boiler pressure is highest, to about 0.6 when the pressure is down.

FIG. 3. THE "HIBERNIAN AUTOMATIC STOKERS" AT THE WOOD WORSTED MILL

This lowering of the pressure is not like shutting a damper off tight. Enough air comes through at the lowest pressure to burn the carbon to CO_2 and there cannot so much get through that thick fire, even at the highest speed of the fans, as to give an excess."

"How do you keep the fans from going over or under that speed?" I asked.

"We have stops on the valves that control them, and when the fires are in good condition that amount of come-and-go will keep the pressure fairly regular."

"Suppose you made so much steam

FIG. 4. THE WOOD WORSTED MILL STOKERS OFF DUTY

with 0.3 of an inch pressure that the safeties blow," I asked.

"In that case we should lay off boilers. And say!" he continued, "there goes another fallacy. We used to think that the more boilers we had and the slower we ran them the better off we were. Lots of heating surface to soak up the heat. The consequence was that you couldn't run your fires hot—they simply mulled and stewed off a lot of gas that went off through the top tubes, and you were paying interest and upkeep on a lot of boilers that were not earning their salt. Now we run the furnaces so as to get all there is out of the coal, get the gas to the boiler good and hot, and then take out what the boiler does not get with an economizer."

"And what do you do when the pressure runs down?"

"We keep enough boilers going to make all the steam we want with less than 0.6 of an inch draft ordinarily. If there should come a sudden temporary pull, it is better to let them draw the steam down a little than to force the fans and blow a lot of excess air through the fires. When the fires have been running for some time they will cake over so badly that 0.6 of an inch draft will not force air enough through them. Then the pressure falls off, and when it gets 15 pounds below normal the whistle blows automatically and everybody goes to slicing."

Reverting to his remarks about slow combustion, I told him that one of our editors had just worked out an easy rule for boiler horsepower. He got it so that it would fit the ratings of a well known builder of horizontal return tubulars nicely. The next time the mechanical engineer of the company was in he showed it to him, and he said that it was all right for the old catalog, but "we rate our boilers on 10 square feet now."

"Well, you can see what we get out of ours," Mr. Diman said, leading me to a framed blueprint report of tests hanging against the brick wall of one of the economizers. I begged the copy of it which is reproduced here.

"The boilers have a little over 2300 square feet of heating surface apiece, and we bought them for 200 horsepower. You can see that in one test (that of October 1, in line 54) we got 316 horsepower out of one of them, and that in none of the eighteen tests did we get less than 200."

"When you burn your coal as completely as those flue-gas analyses show, you are bound to get your heat out of it, aren't you?" he continued. "Well, if you get your heat developed in the furnace there are only three places it can go to—into the steam, up the stack, or out into the room. You don't find much radiation here, do you? A man can eat his lunch comfortably on top of those boilers. There can't be much heat going up the stack with the gases at 200 degrees and that excess of air, can there? How are you going to beat it?"

It did look hard to beat. The stack temperatures were lower on the day that I was there than the values given in the table, but I saw the records being made, in fact Mr. Diman had new charts put on, and the record of the balance of the day's run made so that I could compare directly the flue temperatures with the temperatures of the gases leaving the economizers for the same period of time.

"There's another fallacy that they're going to get over some time," said the

captain, "and that's building great, tall chimneys to pump off the flue gases by the most wasteful method of pumping that you could conceive. What runs a chimney? It is the heat that you put into it, isn't it? If the gas inside of the chimney were no hotter than the air you wouldn't get any draft, would you? And to get draft enough to burn coal you have got to have a good high chimney and keep it full of good hot gas. Instead of putting the flue gases into the chimney at 450 or 500 degrees, I am putting them in at 200 and am heating the water 80 degrees with them. That means over 7 per cent. saving, doesn't it? Well, don't you suppose that with 7 per cent. of the coal that I burn here I can a good deal more than run those fans? And having them I can have any amount of draft that I want any time that I want it, and am entirely independent of wind, weather, barometer, or anything else, so long as I have steam pressure?"

Mr. Diman was one of the first to realize that the boiler room is the place to save fuel, and this is particularly true in a plant in which, like those of which he is in charge, the demand for exhaust steam is so great as to discourage any overreaching for economy on the engine-room end. The thing that struck me particularly about it was the quiet, orderly effectiveness of it all. The men fired not as though they were there to dig a hole in the coal pile, but as though they were intelligent units in an important industial system, and as though they realized that their present occupation was but the initial step to a creditable and remunerative career. Mr. Diman knows the characteristics and the capabilities of his men;

EVAPORATIVE TESTS MADE AT WOOD WORSTED MILLS, LAWRENCE, MASS.

By Arthur D. Little, Chemical Expert and Engineer, Boston, Mass. Coal Department, E. G. Bailey, Chief.

	Average Pressures:																													
8.	Steam, lb. per sq.in	153		153		151		151		152		153		152		151		152		153		151		150		153				
9.	Draft leaving boiler, in. of water	0.99		1.05		1.74		1.14		1.22		1.18		1.25		1.15		1.31		1.36		1.27		1.21		2.15				
10.	Draft over fire, in. of water	0.58		0.50		0.65		0.57		0.69		0.66		0.60		0.52		0.67		0.76		0.73		0.66		0.86				
	Average Temperatures:																													
11.	Fire room, deg. F	87		85		67		76		76		77		82		62		73		79		64		65		63				
12.	Products of combustion leaving boiler, deg. F	496		479		478		478		478		473		489		490		489		477		470		491		520				
13.	Products of combustion entering economizer, deg. F.	443		442		437		440		440		438		440		435		436		435		442		448		440				
14.	Products of combustion leaving economizer, deg. F.	236		237		238		242		242		239		243		239		243		240		241		244		240				
15.	Feed water entering economizer, deg. F	110		112		113		112		112		113		108		114		109		109		107		109		106				
16.	Feed water entering boiler, deg. F	181.6		176		178		181		179		180		180		181		178		178		173		177		178				
	Fuel and Furnace:																	317		493		407		387		480				
18.	Weight of wood for kindling, lb	345		351		855		538		561		369		344		332		11,600		11,800		10,400		14,000		14,600				
19.	Total weight of coal fired, lb	9,600		10,200		11,200		11,200		11,200		10,800		11,200		11,600														
20.	Total weight of coal and equivalent wood fired during test, lb	9,738		10,320		11,342		11,416		11,424		10,947		11,337		11,733		11,727		11,997		10,563		14,155		14,192				
21.	Refuse from grate and cleaning, lb	536		416		546		370		648		626		468		587		568		1,107		540		770		533				
22.	Refuse from ashpit, lb	566		608		656		674		776		599		578		422		378		530		565		454		500				
23.	Total refuse, lb	1,102		1,024		1,202		1,044		1,424		1,225		1,046		1,009		946		1,637		1,105		1,224		1,033				
24.	Weight of clinker from total coal, lb	231		219		231		130		309		263		321		351		278		563		104		240		307				
25.	Per cent. total refuse to total coal	11.5		10.0		10.9		9.3		12.7		11.3		9.3		8.7		8.2		13.4		10.6		8.7		7.4				
26.	Per cent. clinker to total coal	2.4		2.2		2.1		1.2		2.8		2.4		2.9		3.0		2.4		3.4		1.0		1.7		2.2				
27.	Per cent. clinker to total refuse	21.0		21.4		19.2		12.4		21.6		21.4		30.8		34.8		29.4		34.4		9.4		19.6		29.8				
28.	Per hour, weight of coal fired, lb	800		827		933		933		947		913		927		1,016		967		983		873		1,183		1,167				
29.	Per hour, weight of coal fired per sq.ft. grate, lb	20.5		21.2		23.9		23.9		24.3		23.4		23.8		26.1		24.8		25.2		22.4		30.3		29.9				
30.	Per hr., weight of coal fired per sq.ft. heat'g sur., lb.	0.348		0.359		0.405		0.405		0.411		0.397		0.402		0.441		0.420		0.426		0.379		0.514		0.506				
	Analyses (Proximate Analysis):																													
31.	Moisture	0.91		1.00		1.15		1.24		1.54		1.26		1.24		1.33		1.17		1.80		1.58		3.26		1.02				
32.	Volatile	15.51		15.01		16.82		16.77		14.86		15.64		19.42		19.70		17.95		30.85		18.18		22.16		20.87				
33.	Fixed carbon	73.13		72.45		72.06		72.16		71.43		71.72		72.18		70.42		73.82		54.98		69.64		66.53		71.10				
34.	Ash	10.45		11.54		9.97		9.83		12.17		11.38		7.16		8.55		7.06		12.37		10.60		8.05		7.01				
	Ultimate Analysis:																	82.54		71.15		78.29		77.08		82.18				
35.	Carbon	79.63		78.37		79.36		79.30		76.80		77.81		81.94		80.12		4.23		5.04		4.29		4.26		4.40				
36.	Hydrogen	4.13		4.08		4.16		4.17		4.05		4.07		4.45		4.36		3.05		7.10		3.84		7.75		4.11				
37.	Oxygen	2.68		2.73		3.09		3.17		3.87		3.65		3.85		3.87		1.32		1.50		1.55		1.49		1.45				
38.	Nitrogen	1.47		1.45		1.51		1.51		1.44		1.46		1.39		1.36		1.80		2.82		1.43		1.37		0.85				
39.	Sulphur	1.64		1.83		1.91		2.02		1.67		1.63		1.21		1.74		14,426		13,038		13,747		12,937		14,402				
40.	British thermal units	14,046		13,784		13,921		13,966		13,478		13,620		14,433		14,142														
	Refuse:																													
41.	Combustible in refuse from ashpit	23.8		20.7		29.7		39.7		22.9		18.1		30.0		38.7		32.9		24.5		20.7		28.3		27.7				
42.	Combustible in refuse from grate	7.3		10.7		7.5		18.6		9.9		9.4		3.6		10.7		4.2		8.9		12.5		14.9		6.0				
43.	Combustible in total refuse	15.8		16.6		19.6		35.4		16.9		13.6		18.2		22.4		15.7		13.9		16.7		19.8		16.4				
	Water:																													
44.	Per cent. moisture in steam																					0.37		0.53		0.68				
45.	Factor of correction for quality																					0.9970		0.9958		0.9946				
46.	Gallons of water fed to boiler by meter	13,185		13,400		14,350		14,815		14,230		13,815		14,640		15,260		15,610		13,635		13,875		17,070		17,235				
47.	Gallons of water fed to boiler by meter corrected, factor 0.864	11,392		11,578		12,398		12,800		12,295		11,936		12,649		13,185		13,487		11,781		11,987		14,748		14,890				
48.	Weight per gallon of water, lb	8.085		8.107		8.100		8.092		8.098		8.095		8.095		8.092		8.100		8.100		8.115		8.104		8.100				
49.	Equivalent weight of water evaporated, lb	92,104		93,663		100,424		103,578		99,563		96,621		102,392		106,692		109,243		95,427		97,273		119,517		120,615				
50.	Factor of evaporation for boiler	1.0809		1.0867		1.0842		1.0811		1.0833		1.0824		1.0823		1.0811		1.0843		1.0844		1.0895		1.0852		1.0825				
51.	Equivalent water evaporated from and at 212° F., lb.	99,555		101,783		108,880		111,716		107,857		104,583		110,818		115,344		118,453		103,481		105,660		129,155		129,681				
52.	Equival't water evap. from and at 212° F. per hr., lb.	8,296		8,254		9,073		9,310		9,118		8,840		9,174		10,100		9,871		8,623		8,864		10,918		10,807				
53.	Equivalent water evaporated from and at 212° F. per hr. per sq.ft. heating surface, lb	3.60		3.58		3.94		4.04		3.96		3.84		3.98		4.38		4.28		3.74		3.85		4.74		4.69				
54.	Horsepower developed by boiler	243		239		263		270		264		256		266		293		286		250		257		316		313				
56.	H.P. developed above rated per cent	22		20		31		35		32		28		33		46		43		25		29		58		57				
57.	Sq.ft. heating surface per H.P. developed	9.48		9.64		8.76		8.53		8.73		9.00		8.66		8.76		8.06		9.22		8.97		7.29		7.36				
	Evaporation:																													
58.	Pounds of water apparently evaporated per lb. coal.	9.35		9.08		8.85		9.07		8.72		8.83		9.03		9.09		9.32		7.95		9.21		8.44		8.50				
59.	Equivalent evap'tion from and at 212° F. per lb. coal	10.22		9.86		9.60		9.79		9.44		9.55		9.78		9.83		10.10		8.63		10.00		9.12		9.14				
60.	Equivalent evaporation from and at 212° F. per lb. combustible	11.67		11.08		10.89		10.94		11.08		10.91		10.93		10.93		11.14		10.18		11.39		10.36		9.98				
61.	Efficiency of boiler and furnace, per cent	70.2		69.1		66.6		67.7		67.6		67.7		65.5		67.1		67.6		63.9		70.3		68.1		61.3				
	Flue Gas by Volume:																													
62.	Carbon dioxide, CO_2	9.0		9.8		8.9		9.3		9.0		9.0		7.8		8.3		8.9		8.8		8.6		10.1		9.3				
63.	Oxygen, O	11.4		10.5		10.9		10.4		11.2		11.1		12.4		12.1		11.4		11.3		11.6		10.2		10.8				
64.	Carbon monoxide, CO	0.0		0.0		0.1		0.1		0.0		0.0		0.2		0.1		0.1		0.1		0.2		0.1		0.1				
65.	Nitrogen, N	79.6		79.7		80.1		80.2		79.8		79.9		79.6		79.5		79.6		79.8		79.6		79.6		79.8				
66.	Air excess	121		102		109		98		116		114		148		140		122		118		126		96		107				
	Heat Balance:		%		%		%		%		%		%		%		%		%		%		%		%		%		%	
67.	Heat used in evaporation, B.t.u. per lb. coal	9,870	70.2	9,522	69.1	9,271	66.6	9,454	61.7	9,117	67.6	9,223	67.7	9,445	65.5	9,493	67.1	9,754	67.6	8,334	63.9	9,658	70.3	8,808	68.1	8,826	61.3			
68.	Loss due to latent heat of water formed	360	2.6	360	2.6	360	2.6	360	2.6	350	2.6	350	2.6	385	2.6	380	2.7	360	2.5	435	3.3	370	2.7	365	2.8	380	2.6			
69.	Loss due to products of combustion	1,195	8.5	1,105	8.0	1,195	8.6	1,145	8.2	1,120	8.3	1,120	8.3	1,205	8.4	1,215	8.6	1,225	8.5	1,072	8.2	1,160	8.4	1,171	9.1	1,338	9.3			
70.	Loss due to air excess	1,260	9.0	985	7.1	1,160	8.3	975	7.0	1,150	8.6	1,020	7.6	1,560	10.8	1,500	10.6	1,330	9.2	1,100	8.5	1,260	9.2	970	7.5	1,260	8.7			
71.	Loss due to CO and unburned gases					78	0.5	80	0.5					204	1.4	79	0.5	91	0.6	77	0.6	178	1.3	76	0 5	82	0.6			
72.	Loss due to unburned coal	285	2.0	330	2.4	345	2.5	770	5.5	355	2.6	255	1.8	230	1.6	355	2.5	185	1.3	285	2.2	300	2.2	285	2 2	200	1.4			
73.	Loss due to radiation, absorption, etc	1,076	7.7	1,482	10.8	1,512	10.9	1,182	8.5	1,396	10.3	1,652	12.0	1,404	9.7	1,120	7.9	1,481	10.3	1,735	13.3	821	6.0	1,262	9 8	2,316	16.1			
74.	Total	14,046	100.0	13,784	100.0	13,921	100.0	13,966	100.0	13,478	100.0	13,620	100.0	14,433	100.0	14,142	100.0	14,426	100.0	13,038	100.0	13,747	100.0	12,937	100.0	14,402	100.0			

he never hires a man from the outside when he has a man inside who can fill a better job; he has an interest in them as individuals, is anxious to teach them all they will absorb and to help them to profit by what they have learned. I found out that a number of boys who had come to him as firemen and helpers owed their ability to read and write to his teaching, and it is characteristic both of his disposition to advance his own men and of his high appreciation of the importance of the fire room that he has selected the head fireman of the Washington mill to be the chief engineer of the new Ayer mill, an uptodate turbine plant of 5000 kilowatts with all of the modern developments.

Cleanliness in Power Plants

In the Public Service Journal *Thomas J. Walsh briefly points out to what extent the cost entering into the production of power may be affected by the proper attention to cleanliness about the power station. His suggestions are well worth careful attention.*

The added exertion necessary to keep equipment and building tidy and free from accumulation of dirt, with all its attendant influences on the deterioration of the apparatus, is so slight, while the benefits are so marked, that there can be no question as to its expediency. No one will deny that the replacing of tools and supplies in their proper places, the removal of foreign matter from any part, the gathering up of waste scraps for easy disposal, the tightening of a loose joint or the replacement of a fractured pipe or fitting in the oil piping, require but the minimum of attention at the appropriate time. Few things are more disheartening to an engineer than the wail of a "dying" turbine, or the laying down of an engine under load, especially with the tools scattered about the plant. Then, too, when the cleanliness of engines and boilers is neglected, the increase in coal consumption becomes at once noticeable; and where there is leaky oil piping, the oil bills must increase as oil is thrown about the engine-room floor and into flywheel pits, or into generator windings and commutator with destructive effects, especially when the cleaning is neglected.

No stronger proof could be brought forward as to the efficacy of the attentions as urged here in this article than the consideration of the power plants of Holland. The wonderful economic results obtained from the obsolete equipment in those stations was remarked some time ago by the editor of the *Street Railway Journal,* and together with these economic results was mentioned the remarkable cleanliness of everything about the plant, not only superficially, but of the invisible parts as well.

And in our own country it is only necessary to observe those stations where economy in the production of power is the aim of the entire personnel, to obtain added proof as to the advantages of cleanliness. One need not look for highly polished brass railings or nickel-plated tools, but one does find no waste of oil, every tool in its place, an orderly supply cabinet or locker, convenient receptacles for clean and dirty waste, drip pans under the auxiliaries, neat piles of coal, feed pumps and lubricators free from accumulation of dust. These will be the most marked, but it is safe to predict that these visible signs are faithful indications of an excellence in the maintenance of the internal parts of the equipment.

As affecting the costs entering into the production of the output, the boiler room contains great possibilities of economic results where cleanliness is properly attended to. The confining of coal in neat piles on the firing floor, or in the containing cars, is not only pleasing to the eye, but firing and the cleaning of fires are simplified by the freedom afforded the firemen in moving about, and furthermore the coal does not become mixed with the ashes. Clean fires and clean ashpits mean efficient combustion as well as increased capacity. Clean drums and tubes, internally and externally, are likewise necessary for efficiency, an instance being known where an ordinarily well operated station increased its rate of coal consumption 2½ per cent. by neglecting the daily blowing or dusting of tubes for a week. And aside from the reduced coal consumption this cleanliness means longer lived grates and tubes, with the resulting decrease in maintenance charges. Clean feed pumps, plungers or rods, protected or kept free from grit, insure a longer life to those parts, as well as a reduction in charges for packing; while lubricators similarly attended to provide clean oil at all times to still further reduce the friction to be overcome. And increased friction means increased coal consumption.

In the engine room a systematic overhaul and cleaning of all parts, internal as well as external, reduce maintenance charges to a minimum, the consequence being increased useful life to the machine. Inspection of engine cylinders and turbine rotors discloses accumulation of carbon, scale and other foreign matter that may easily counteract much of the care devoted to the boiler-room equipment previously mentioned. Carbonized oil, due to an excess of lard or tallow, or metal flake carried over from the boilers with the steam, while blocking up steam ports of valves, is also sure to cause scored cylinders; and under certain conditions blades of turbines will accumulate scale to a degree hardly imaginable, but which is only disclosed by inspection, such a condition being obviously destructive of all the refinements accorded to the previous stages in the chain of conversions. Bearings, pins and boxes likewise need only to be examined to bear out this discussion, indicating the necessity for frequent cleaning of oil grooves if lubrication is to be effective.

This argument extends to the other machines making up the engine-room equipment.

Care should be given to offices and workshop in the same way; the effect of such a general scheme of cleanliness could not but be beneficial to each member of the operating crew.

As affecting the fixed charges, the surplus capacity in a plant could reasonably be lower where operating engineers of a high grade were known to be in charge, men who would insist upon the maintenance of all equipment in first-class operating condition. In this way the investment charges might be materially reduced. As to the depreciation charges, the assumption of a continued régime of cleanliness would hardly justify a reduction; yet to find at the end of its useful life in a particular station—or when it shall have been superseded—that the depreciation on a machine has been overestimated, is a much more satisfactory outlook than would be the reverse.

So, too, oily waste thrown around and oil-saturated floors—particularly in wooden structures—increase the fire risk, and this must be provided for by a higher insurance rate.

Granting then the improved efficiency of the equipment, as well as of the men, and the possible reduction in investment, depreciation and other fixed charges, it becomes obvious that for the successful operation of a power station the first essential is cleanliness.

A systematic and careful cleaning of every piece of apparatus in use in the station will in the beginning disclose weaknesses to be attended to before becoming too serious. The application of a wrench to a loose nut or bolt, or the careful cleaning of electrical apparatus from oil, might easily prevent highly destructive consequences. This attention should be given not only to the main units but also to pumps, heaters, condensers, all piping, traps, oil tanks, filters, water-measuring devices, scales, motors, etc.

Measurement of High Temperatures

By A. R. Maujer

With appreciation of the value of exact information relative to boiler operation comes a demand for instruments to measure the temperatures at various points in the boiler and flue. The six principal types of pyrometers available for boiler-plant use are described.

Pyrometry, or the measurement of temperatures above the range of the ordinary thermometer, has but recently become available for industrial uses. In many manufacturing processes the desirability of accurate temperature observations was recognized long before any pyrometer of practical value had been developed. At the present time, however, there are several types of pyrometers which are very satisfactory for commercial as well as scientific uses, and in some branches of industry the pyrometer has become indispensable. New uses for it are constantly being found. Its value in economical boiler operation is being more widely recognized. Indeed, it requires no great stretch of imagination to foresee the time when the pyrometer will be a device as familiar to the fireman as is the steam-pressure gage today.

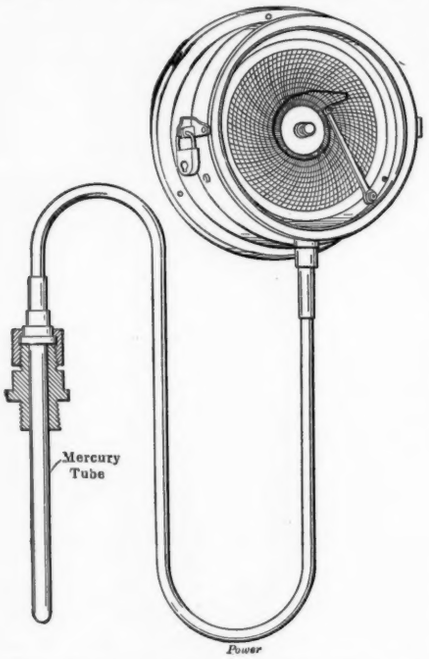


FIG. 1. MERCURIAL PYROMETER WITH RECORDING GAGE

Six principal types of pyrometers available for boiler-plant work will be discussed, to wit:

Mercurial.
Expansion.
Calorimetric.
Electric.
Pneumatic.
Optical.

MERCURIAL PYROMETER

In the mercurial pyrometer a portion of a tube is filled with mercury and the remaining space with nitrogen gas. At atmospheric pressure, mercury will boil at 675 degrees Fahrenheit. As the tube is heated the mercury expands and compresses the nitrogen, the resultant increase in pressure on the mercury raises its boiling point. These pyrometers are made in many styles of both portable and stationary form. The end which contains the nitrogen may terminate in an ordinary pressure gage calibrated in degrees of temperature; such an instrument is more easily read than one which has only the ordinary thermometer type of scale. In place of the indicating pressure gage a recording gage may be used from which a chart can be taken showing the temperature changes throughout each twenty-four hours. In Fig. 1 is shown a typical mercurial pyrometer with recording gage and flexible connection tube.

Mercurial pyrometers are accurate, durable and cheap. They are excellently adapted to measuring uptake and chimney temperatures. They are constructed to read as high as 1000 degrees Fahrenheit.

EXPANSION PYROMETERS

The difference in the rate of lineal expansion of two metals is the principle upon which expansion pyrometers are based. For the same rise in temperature, copper expands 50 per cent. more than iron. In the expansion pyrometer a tube of copper is inclosed in a tube of iron. At the end to be heated the tubes are securely fastened to each other. At the other end they are attached to a set of multiplying gears which actuates a needle pointer over the face of a properly calibrated dial. It is necessary to expose the entire length of the expansion tubes to the full effect of the heat to be measured; if this is not accomplished, error will result as the proper amount of elongation has not been obtained. When the pyrometer is first inserted, the pointer will act rapidly in one direction or the other and give an untrue reading temporarily. This is caused by the outer tube heating and expanding more rapidly than the inner one. As soon as the inner tube heats up and expands proportionately, the pointer will correctly indicate the temperature. When an expansion pyrometer has been used repeatedly for temperatures near its limit, the indicator will no longer return to the position indicating the temperature of the atmosphere. A permanent change has taken place in the length of one of the tubes. By loosening a set screw the dial may be shifted to correct the variation.

A standard type of expansion pyrometer is shown in Fig. 2. In spite of the fact that these pyrometers get out of calibration rather easily they are capable of giving close results if understood and carefully handled. They will indicate temperatures as high as 1500 degrees Fahrenheit.

CALORIMETRIC PYROMETERS

The method of indicating temperature by the calorimetric pyrometer is the same as that of indicating specific heats by the water calorimeter. In one case, from the known temperature the specific heat is calculated; in the other case, from the known specific heat the temperature is calculated.

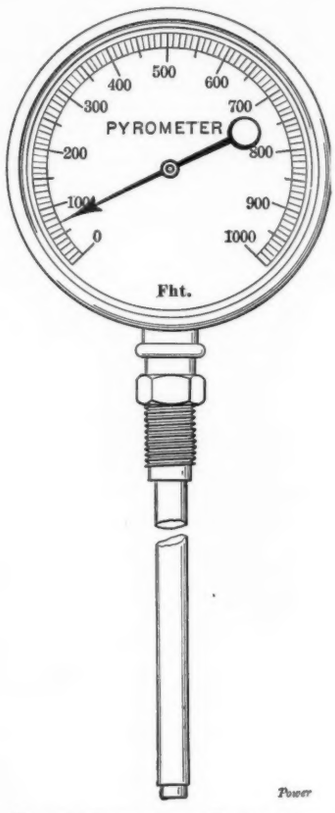


FIG. 2. EXPANSION PYROMETER

A given weight of some metal, the specific heat of which is known, is heated to the temperature to be measured and then instantly plunged into a known weight of water. The rise in temperature of the water is noted. The formula for finding the temperature is:

$$X = T + \frac{W\,t}{w\,s}$$

in which,

X = Temperature to be measured in degrees Fahrenheit;
T = Final temperature of the water;
W = Weight of the water in pounds;
t = Rise in temperature of the water;
w = Weight of the metal, in pounds;
s = Specific heat of the metal.

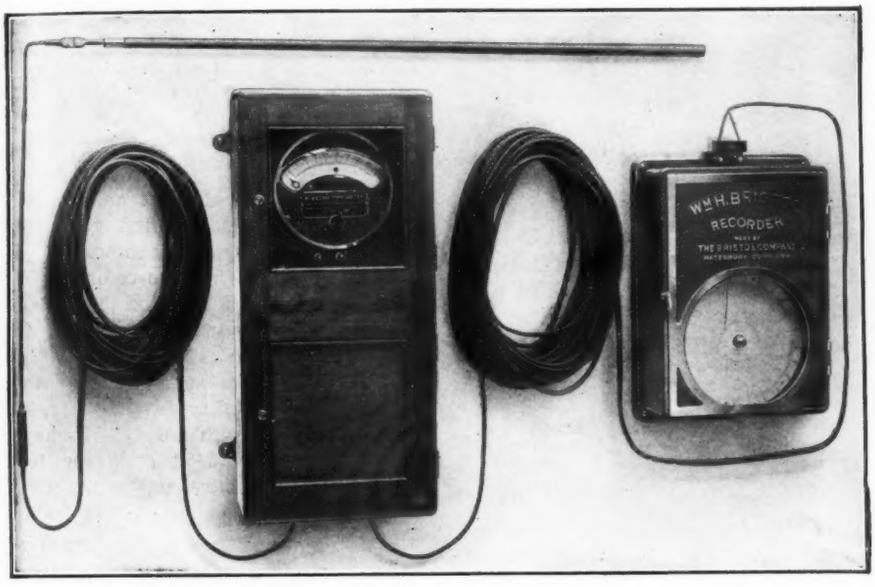


FIG. 3. ELECTRIC PYROMETER WITH INDICATING AND RECORDING GAGES

A calorimetric pyrometer is an apparatus by means of which the temperature may be found without using each time the formula previously given. It usually consists of a copper cup which is insulated to prevent loss from radiation and which has gage marks upon it for a definite amount of water. Fastened to the cup and so arranged as to be properly immersed, is a small thermometer. A sliding scale is attached to the thermometer. A copper or platinum ball completes the outfit. The scale on the thermometer is calibrated with the quantity of water which the instrument holds and

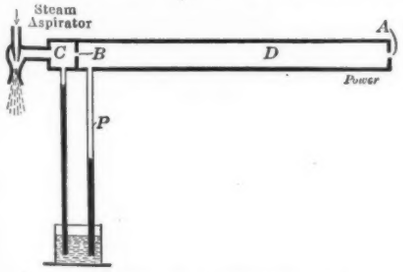


FIG. 4. DIAGRAMMATIC SKETCH OF PNEUMATIC PYROMETER

with the metal ball so that the rise in temperature of the water causes the thermometer to indicate correctly the temperature being measured.

This pyrometer is very liable to inaccuracy. The results which it gives vary with the skill and care used in its manipulation. Its cheapness and portability, however, recommend it where approximate results are satisfactory. It may be used for temperatures up to 3000 degrees Fahrenheit.

ELECTRIC PYROMETERS

When rods or wires of two dissimilar metals are joined at one end, they compose a thermoelectric "couple" or "element." When the junction is heated, a difference of electrical pressure is established between the cool ends. If a circuit is made by joining the cool ends together, either directly or by means of a conductor, a current will flow. The strength of the current depends upon the nature of the "element" and the difference in temperature between the hot junction and the cool ends or cold junction. The deflection of a galvanometer placed in the circuit may be calibrated, then, to indicate the temperature at the hot junction.

An electric pyrometer consists of the thermoelectric couple, the galvanometer and a device for compensating for the changes in temperature at the cold junction. In most makes for commercial use, this change is taken care of by shifting the scale on the galvanometer a few degrees one way or the other when the temperature at the cold junction is observed to change appreciably. Fig. 3 shows an electric-pyrometer outfit having both an indicating and a recording gage.

Electric pyrometers are adaptable to many uses. With proper handling they will give accurate results. Their great advantages are convenience and simplicity. A disadvantage is delicateness. Where high temperatures are measured and continuous service required, the cost of upkeep may be considered another disadvantage. Depending on the composition of the thermoelectric element, electric pyrometers will measure temperatures up to 3000 degrees Fahrenheit.

For temperatures up to 1100 degrees, the element is made of nickel and constantan; for 2300 degrees, nickel and a special carbon are used, and for 3000 degrees, platinum and platinum-rhodium make up the element.

PNEUMATIC PYROMETER

Under constant pressure the volume of air varies with the temperature. The pneumatic pyrometer makes use of this principle. Fig. 4 diagrammatically illustrates its operation. Due to the resistance of the small apertures A and B, the steam aspirator, working at a uniform rate, causes a partial vacuum in chambers C and D. If A and B are of the same size and if the air remains at a fixed temperature, the same amount of air will pass through each aperture during a given length of time and the suction in chamber C will be practically twice that in chamber D. If, however, the air is heated when it passes through A, but again cooled to a lower fixed temperature before it passes through B, more air will pass through B than through A during the same time. The effect will be to increase the suction in chamber D. In the same way, every change in temperature of the air flowing through A will have its influence on the amount of vac-

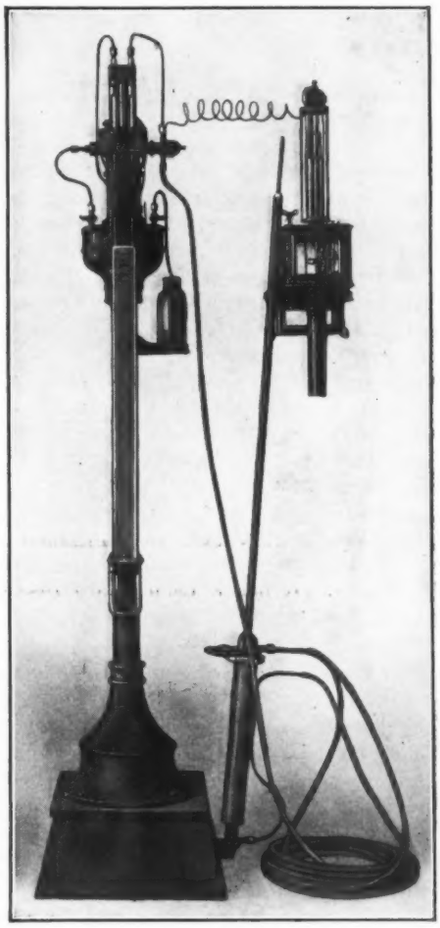


FIG. 5. THE PNEUMATIC PYROMETER WITH RECORDING GAGE

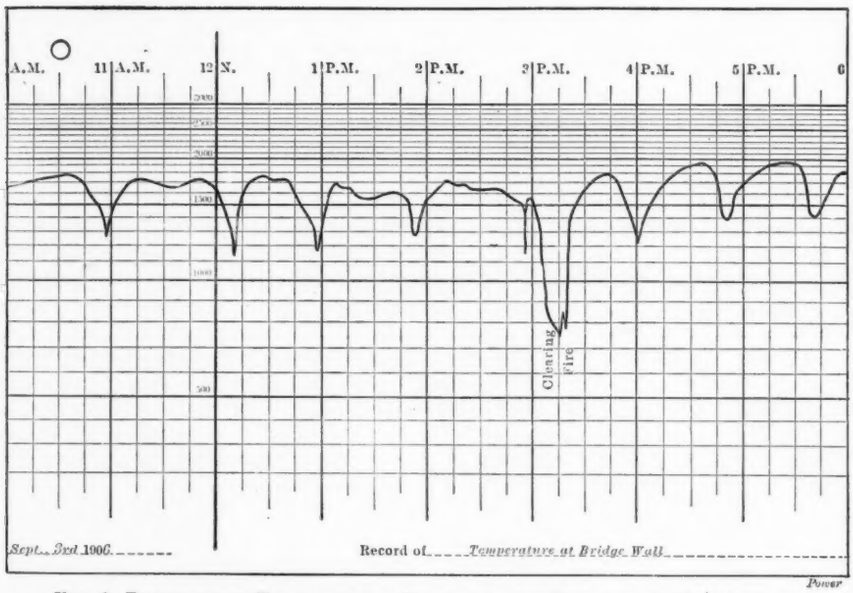


FIG. 6. EIGHT-HOUR TEMPERATURE RECORD FROM PNEUMATIC PYROMETER

uum in chamber *D*. Thus the manometer tube *P* may be calibrated to indicate the temperature of the air passing through *A*.

Fig. 5 shows the pneumatic pyrometer. The recording gage is simply a light-vacuum-recording gage which makes a record on a long paper tape carried on rollers. A record can be taken to cover a period of any length of time. Fig. 6 shows an eight-hour record of the temperature at the bridgewall of a hand-fired return-tubular boiler furnace burning a small size of anthracite.

That it is not portable is the most serious disadvantage of the pneumatic pyrometer. In its favor are accuracy and durability. It has a temperature range up to 3000 degrees Fahrenheit.

OPTICAL PYROMETERS

Estimating temperatures by the intensity of light radiated from a heated body is probably the oldest effort at pyrometry. Until recently, the only apparatus was the human eye "calibrated" by long practice. Study of the laws of radiation from incandescent bodies has led to the development of the optical pyrometer, an instrument which eliminates practically all error to which the eye is liable.

WANNER PYROMETER

In the Wanner optical pyrometer, by means of a series of lenses and prisms, the red rays of the light from the source of heat to be measured are compared with the red rays of the light from an incandescent lamp which is carefully maintained at a given brilliancy. The rays from each source are polarized in planes at right angles and viewed through a nicol analyzer. The analyzer is rotated until both sets of rays are of equal brightness. The angle of deviation from the normal position is calibrated in degrees of temperature.

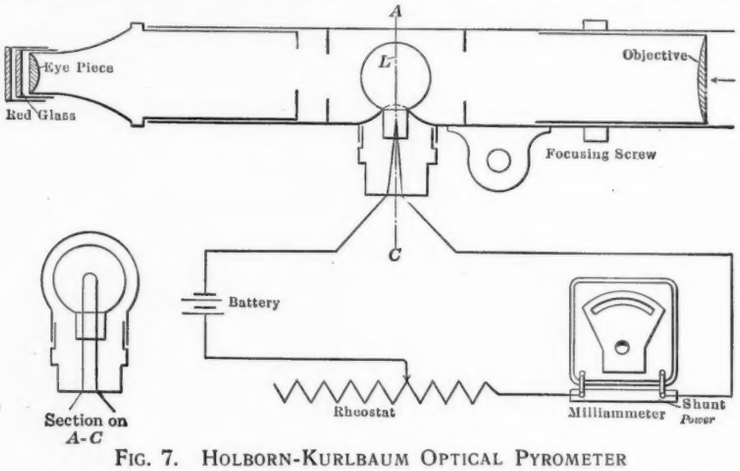


FIG. 7. HOLBORN-KURLBAUM OPTICAL PYROMETER

LE CHATELIER PYROMETER

In the Le Chatelier pyrometer, instead of adjusting the two sets of rays to equal brightness by means of a polarizing device the rays from the source to be measured are intercepted by a cat's-eye diaphragm which is adjusted until the two sets of rays correspond in brilliancy. The size of the opening in the diaphragm is calibrated to indicate degrees of temperature.

HOLBORN-KURLBAUM PYROMETER

When a circuit of gradually increasing strength is passed through an incandescent lamp, the filament first glows red, then changes successively to orange, yellow and white. When the color of some part of the filament matches the radiated light the current passing through the lamp at that time is a measure of the temperature of the source of radiation. In the Holborn-Kurlbaum pyrometer, Fig. 7, a 4-volt lamp with a simple U-shaped filament is mounted at *L* in the focal plane of the objective and eye piece of a telescope. The radiating light is focused in the plane *A C*. The current through the lamp is varied until the tip of the filament seems to disappear against the bright background. The milliammeter is calibrated to read directly in degrees of temperature. The red screens over the eye piece are used when the temperatures to be measured are so high as to produce a brilliancy uncomfortable to the eye.

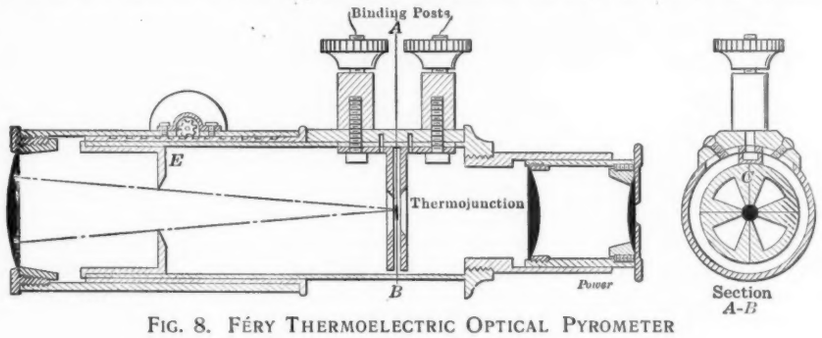


FIG. 8. FÉRY THERMOELECTRIC OPTICAL PYROMETER

FÉRY PYROMETER

In Féry's pyrometer the total radiation from the incandescent source is focused on a small thermocouple which is connected to a sensitive galvanometer and acts in the same way as the ordinary direct-contact electric pyrometer. The Féry pyrometer is shown in Fig. 8.

In general, it may be said that all optical pyrometers, being very delicate instruments, depend for their usefulness upon great care and intelligence in handling. They must frequently be calibrated and in most cases this cannot be done outside of the laboratory. For these reasons they are not well suited to ordinary use in the boiler room.

Development of Chain Grate Stokers

By J. F. Springer

The original chain-grate stoker was brought out in England by Juckes in 1841. The basic principles of which it made use are employed in the present-day types. An important feature of the modern chain-grate stoker is the flat combustion arch.

As far back as 1841, the British government granted to Juckes a patent for a traveling chain-grate stoker. About thirty years later, September 5, 1871, an American patent was issued to Royal F. Weller, of Albany, N. Y., for a similar device. This was, apparently, the first American stoker of this type, and for that reason it demands our attention, for chain-grate stokers have come into very extensive use indeed. Details of Weller's device are shown in Fig. 1. It will be noticed that this stoker differs from that designed by Juckes in the arrangement of

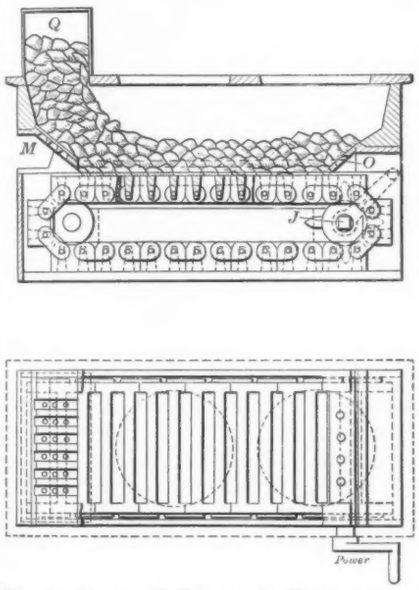


FIG. 1. ROYAL F. WELLER'S CHAIN-GRATE STOKER

the bars which go to make up the grate. Juckes arranged his longitudinally, while Weller placed his transversely. This effects a complete change in the method of connecting them. In Juckes' machine they were strung upon bars. Weller had them connected (see longitudinal view) by links working on studs projecting from the bars which, it will be observed, were cast in pairs. A little reflection will convince one that these studs, exposed as they would be to very severe temperatures, would be liable to severe damage. However, Weller provided that they should be of wrought iron, the grate bars being, in fact, cast around them. The motion of the ribbon of bars is accomplished by rotating one of the drums *J*, upon which it is arranged. Cogs or teeth project radially from suitable points around the ends of the drum body and engage the space between the members of a pair of bars. Two inclined grate surfaces *M* and *O* were arranged at either end of the upper surface of the ribbon. A hopper *Q* was placed at the front and above one of the inclined grates. If we recall James Watt's device of 1785, which was not a stoker but a furnace, we shall see that the hopper *Q* corresponds to the fuel chamber, while the grate *M* has its counterpart in the front opening in Watt's furnace. Here the similarity ceases, for the American's chain-grate device did not permit complete combustion to take place here, but carried the coal on toward the rear. It will be seen, however, that both devices operated to coke the fuel, before igniting it. The rear plate is hinged and may be raised to permit the moving ribbon to carry off any unconsumed fuel.

This cross-bar method of fabricating the grate dispensed, it is true, with the stringing of a considerable number of bars on a single rod. This is, no doubt, a gain from one point of view. Still the operation of the longitudinal, interlaced bars of Juckes' machine had the advantage of stripping off clinkers as they passed over the rear drum. In patents issued to Simon Regan, of England, in Great Britain in 1874 and in the United States in 1877, the advantages of both methods of construction were obtained. This will be understood upon consulting Fig. 2, where the grate surface is shown. Each bar consists of a transverse rod having double arms arranged at intervals longitudinally. This device had the merit of breaking the fabric up into a number of individual units which could be detached with some approach to ease, and which yet effected the clinker-stripping movement in passing around the rear drum.

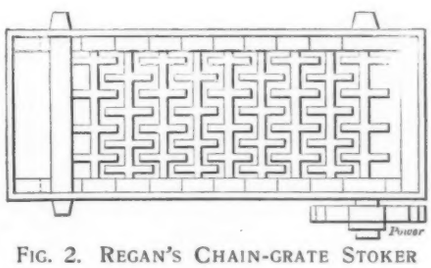


FIG. 2. REGAN'S CHAIN-GRATE STOKER

Eckley B. Coxe, of Drifton, Penn., was a rather prolific inventor and gave attention, among other things, to the question of the burning of coal in furnaces. With him, the coal in mind was particularly the smaller grades of anthracite. On June 20 and December 12, 1893, Mr. Coxe had issued to him as sole inventor no less than 26 patents upon distinct inventions relating to the question of fuel consumption. These patents were followed by still others up to the time of his death in about 1896. The traveling grate was the type upon which he spent his time. In what are, apparently, the two earliest of his patents (both June 20, 1893), Coxe provided an endless grate ribbon formed of sections composed of several transverse bars linked together at the ends. This ribbon was driven by wheels provided with cogs which coöperated with notches in the under side of the chain links. A striking characteristic of this stoker is the system of air supply. By referring to Fig. 3 a series of transverse air compartments *A, B, C, D,* located immediately below the grate surface, may be seen. These compartments

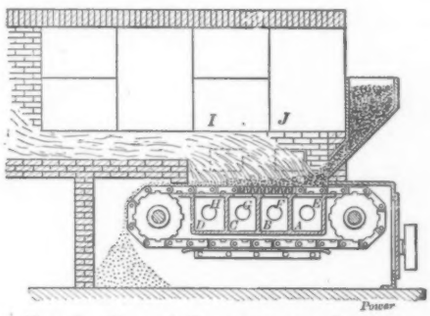


FIG. 3. COXES' CHAIN-GRATE STOKER

were supplied by separate pipes, *E, F, G, H,* which could be controlled independently of each other. The object of this arrangement was to vary the pressure of air from point to point as the fuel receded into the furnace, the idea being that combustion would thus be carried on more perfectly, precisely that amount of air being supplied that experience and observation showed to be most effective at the various stages through which the fuel passed. Observation doors *I* and *J* were provided for the purpose of enabling this control to be carried out.

Coxe seems to have thought quite a variety of forms of grate to be possible. One form is an elaborate system of overlapping perforated plates, invented jointly by him and another. These plates were so supported and arranged as to separate and discharge from one to another as they passed around the rear wheel. It was thought that by this means the ashes and cinders would be discharged without clogging the mechanism.

As Juckes' British patent of 1841 was really the first disclosure of the chain grate, this inventor was the origi-

nator of a very important permanent idea in mechanical stoking. Without taking into account the sales of other chain-grate stokers, the importance of this type is shown by the fact that a single concern has already equipped a total boiler capacity of over 1,000,000 horsepower. The fundamental idea, which is at least 68 years old, is thus seen to have been commercially correct.

But, while Juckes, if he were still alive, could find a chain ribbon mechanically operated to carry the fuel through the furnace, he would see that the latest models differ from his in many important details. He would conclude that his idea of longitudinal interlocking grate bars must have been a good one, seeing that this style of bar has been returned to, although intervening history discloses attempts to depart from it. Upon examining the fabric of the modern chain grate, he would discover that his method of semi-permanently stringing the bars had been entirely abandoned for a system permitting the quick removal of any individual bar without the withdrawal of any cross bars. Remembering that ordinarily it was necessary with his machine to withdraw, partially at least, two rods, he would, no doubt, be impressed with this feature.

In order to understand just how the idea of individual removability is carried out in practice, reference should be made

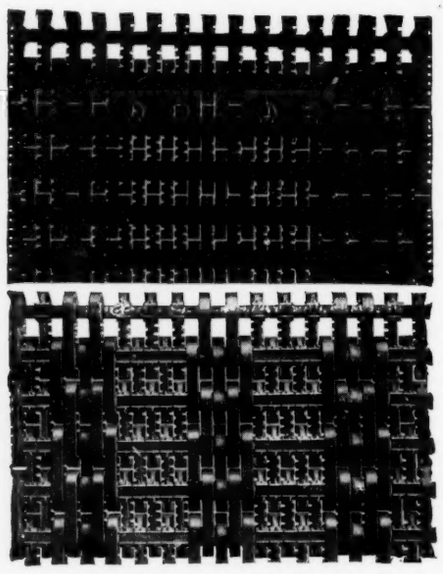


FIG. 4. UPPER AND UNDER GRATE SURFACE

to Figs. 4 and 5. In Fig. 4 are shown the upper and under surfaces of a portion of the grate fabric. The vertical direction in the figure corresponds to the longitudinal direction in the furnace. By looking closely at the upper view, two loose links may be seen. The form of these is exhibited more clearly by the uppermost link shown in Fig. 5. All of the links in the fabric are of this style except those on the outer edges. These

FIG. 5. VARIOUS FORMS OF LINK

are of the style of the second and third links from the top in Fig. 5. The cross bars which bind the links into a whole are somewhat flattened in form. These bars may be seen in the lower view of Fig. 4. It will be seen that by turning the bars on their edges, the inner links may be individually removed or inserted. The outer links present no difficulty. These outer links, it may be remarked, must be removed before attempting to turn the bars. When these links are in place together with the cotter pins, the whole fabric has its integrity maintained. When making the rounds at the ends, the external links and the internal ones abreast of them, all remain fixed relatively to their cross bars. But the transverse row of connecting links turns somewhat on the rods. These connecting links must, therefore, all be interior ones with their more or less circular slots. That the connecting links are all interior ones may be seen by consulting Fig. 4. An inspection of the lower view in this figure shows that some of the interior links and all of the exterior ones have a straight under surface. This is to facilitate the movement of the whole ribbon on the dead rollers which support it between the sprocket wheels at either end. In the stoker in which this grate is used, if the width of the grate surface exceeds 7½ feet, two ribbons are used side by side. In this case, the links which form the adjacent edges of these ribbons are made of the special forms shown in the case of the two links at the bottom of Fig. 5. This is to permit the turning of the cross bars without their removal. It will be observed that there may be a relative movement of the links among themselves as they round the ends of their course. This is effective, just as with the old Juckes' type, in removing clinkers.

As the whole grate moves slowly round in its circuit, the links are completely overturned, so that their under surfaces are uppermost as they pass from the rear to the front. Right here is where attention to detail is necessary. The material sifting through from the upper grate surface will, some of it, lodge on the lower portion and perhaps tend to clog the under surfaces of the links. This would occasion difficulty at the sprocket wheels. Consequently, these latter are

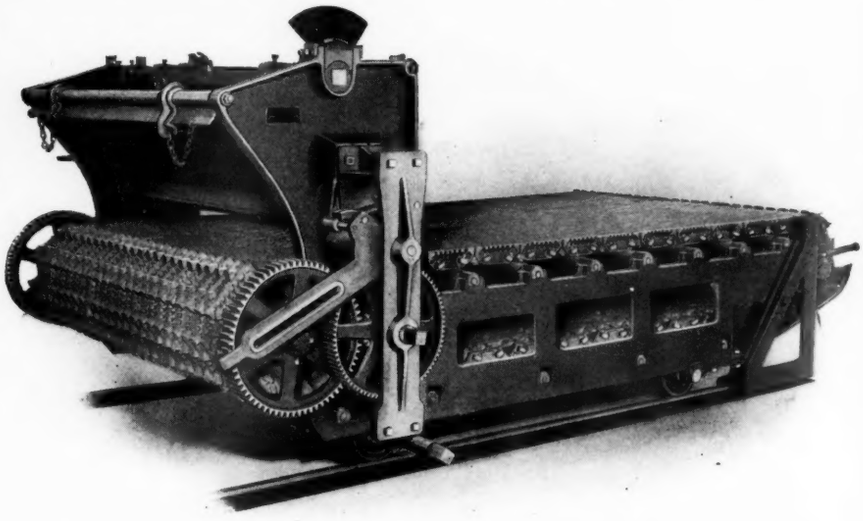


FIG. 6. THE GREEN CHAIN-GRATE STOKER

hollowed out between teeth to insure a correct seat for the driving links.

By referring to Fig. 6 the complete stoker may be seen. It will at once be observed that the frame has its upper edges much below the grate surface. This is very important, as it is thus that protection from the excessive temperatures of the fire is obtained. It will be noticed that by means of the track the entire machine may be run into position. The usual length of the grate surface is 9 feet from the point where ignition occurs to a point above the rear sprocket shaft. For special conditions, longer surfaces are employed up to 12 feet. The feed gate, which is arranged to operate vertically at the rear of the hopper for the purpose of regulating the amount of fuel passing into the furnace, is protected from the effect of the heat of the fire by an inner facing of tiles. Trouble has, in the past, been found to arise from the fire penetrating forward into the hopper. The skeleton device for the support of the tiles and the tiles themselves are so arranged mutually that the latter may be removed or inserted individually and the bracket may be effectually protected.

A detail of considerable importance relates to the ignition arch. Under the older systems, this was curved. A very serious objection was the variable distance between arch and grate. Indeed, this difficulty was so serious as practically to limit the width of chain-grate stokers. And this in turn tended to restrict efficiency. A proper ratio between grate surface and heating surface is necessary to secure the best results. The modern chain-grate stokers may be installed with perfectly flat arches. The construction of the Green arch will be understood from Fig. 7. Two channels are placed transversely across the fore part of the furnace roof. A series of small I-beams are arranged connecting the two channels and depending from them. Specially formed bricks of refractory material are slipped in between the I-beams and supported by them. By means of this construction, the stoker may be installed having any width of grate surface without involving variations in the distance to the ignition arch. Thus, an evenness of conditions of combustion is brought about at the very start. Further, this style of arch is said to be more economical to maintain. It will be noticed that each brick sustains nothing but its own weight. There is no stress or strain induced by contraction or expansion. The flat arch is a notable step in the development of the chain-grate stoker.

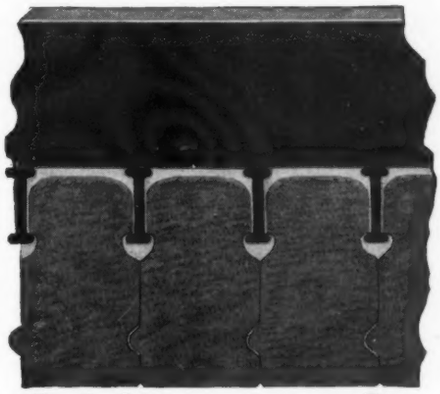


FIG. 7. CONSTRUCTION OF THE FLAT COMBUSTION ARCH

Cold and Its Production

By F. E. Matthews

In this article the subject of heat is discussed, its effects, as in producing change of temperature as well as change of state of matter, units by which it is measured, its absorption in the process of evaporation of liquids, laws which govern its flow from one body to another, and their application to both natural and artificial processes of refrigeration.

In its broadest sense, refrigeration may be defined as the process of cooling; or, since cold is simply the absence of heat, as darkness is the absence of light and dryness the absence of moisture, in which cases the real entities are heat, light and moisture respectively, refrigeration may be more accurately defined as the process of extracting heat.

The study of refrigeration, therefore, necessitates the study of heat. The above definition is, however, somewhat inadequate in that it conveys the impression that heat is a passive element, while on the contrary, it is inherently an active one. While heat may be generated by the performance of work, as when we compress gases or even when we strike a piece of metal a few sharp blows with a hammer, its appearance being incident to the disappearance of an equivalent amount of work. When once fortified within the walls of matter it is able to resist the most strenuous efforts to dislodge it, with the result that it must be decoyed into leaving the substance from choice. Heat can best be dislodged from one substance by placing near it another materially lower in temperature, in which case heat will flow from the substance having the higher to that having the lower temperature, just as water flows from a higher to a lower level. The result of the gravitation of heat from the substance having the relatively higher to that having the relatively lower temperature, is that the latter is heated and the former refrigerated. Since wherever there is a difference in temperature between two substances there is always a tendency for heat to flow toward that of the lower temperature, both heating and refrigerating may take place at any point above absolute zero.

Since refrigeration has to do wholly with the extraction of heat, in order to arrive at a clear understanding of the subject, one must first become familiar with the general thermal properties of the substances most commonly employed in the process, such properties for example, as their capacity for absorption of heat under different conditions.

Matter may exist in three different states; the solid, the liquid and the gaseous, according to the amount of heat which it contains.

The molecular theory of matter briefly stated, is that all matter consists of minute particles called molecules, the smallest division which retains the properties of the substance; the molecules are in turn made up of smaller particles called atoms, which may vary greatly in character. For instance, water (H_2O) is made up of molecules, which are composed of atoms, not of water, but of hydrogen (H) and the oxygen (O).

The kinetic theory holds that these molecules and atoms are in constant motion, in a much restricted way in the solid, that they move with slightly more freedom in the liquid, and with comparatively great freedom in the gas. The application of heat, supplying to the molecule certain energy, so that its motion is increased will cause the transition from the solid to the liquid and finally to the gaseous state. It follows that the removal of heat will have the opposite effect of reducing the gas back to the liquid and the liquid to the solid state, as the energy is withdrawn from the molecules.

Heat may effect change in condition as well as changes of state of matter. For example, the application of heat to a piece of iron first effects a change in its condition, i.e., increases its temperature. When the melting point is reached the further application of heat effects a change from the solid to a liquid state. A solid substance will absorb a certain

definite amount of heat for each degree of rise in temperature, and the ratio of the amount of heat absorbed, per unit of weight per degree rise in temperature, to that of water, is known as the "specific heat of the solid."

When the melting point is reached the further application of heat will produce no appreciable rise in temperature until all is melted, and the amount of heat absorbed, divided by that amount required to increase the temperature of a unit weight of water one degree, is the "latent heat of fusion," or "latent heat of the liquid."

When all of the substance is melted the further application of heat will again produce a rise in temperature and the ratio of the amount of heat absorbed per unit weight per degree rise in temperature to that of water is "the specific heat of the liquid."

When the boiling point of the simple* substance in question is reached, the further application of heat will produce vaporization, which will progress at a constant temperature until all is evaporated and the ratio of the amount of heat absorbed to that required to raise the temperature of a unit weight of water one degree is the "latent heat of vaporization of the liquid," or "latent heat of the vapor."

Objection might logically be made to the term latent heat since the heat disappearing when solids melt and liquids evaporate really no longer exists as heat, but has been expended in doing work, just as heat units expended in a steam engine are converted into an equivalent amount of work measurable in foot-pounds. A common example of this is the raising of a weight of a certain number of pounds through a certain number of feet of space against the attractive force of gravity. Heat absorbed in the process of melting and evaporation is expended in doing interior work, or in overcoming gravitational forces between the molecules of the substance melted or evaporated. The expenditure of heat in separating one molecule from another against the force of molecular gravity, differs in no material sense from that expended in prime movers in separating heavy weights from the earth against the force of gravity.

When all the substance is evaporated the further application of heat will again produce a rise in temperature and the ratios of the amount of heat absorbed per unit of weight per degree of rise of temperature of the gas is the "specific heat of the gas."

*In the case of complex substances, such, for example, as mineral oils, no absolutely fixed boiler points exist. A moderate application of heat to crude oil will drive off one after another of the distillates, such as benzine, gasolene, kerosene, etc., but while the temperature at which each distillate is driven off is different from that of the others, the increase in temperature as distillation progresses is gradual and that distillation temperatures define the product, rather than the product the temperatures.

The standard unit generally adopted in commercial work among English speaking people is the British thermal unit (B.t.u.) which is the equivalent of the amount of heat required to raise the temperature of one pound of water through one degree Fahrenheit at its temperature of maximum density, 39.1 degrees Fahrenheit. This, it will be remembered, Joule found by his historic experiment to be equivalent to 772 foot-pounds of work. More recent experiments, however, have led to the adoption of 778 as a more accurate equivalent. In more purely scientific work the French or metric unit, the calorie, is employed. This unit is the equivalent of the amount of heat required to raise the temperature of one kilogram (2.2 + pounds) of water through one degree Centigrade (1.8 degrees Fahrenheit) at its maximum density, a temperature of four degrees Centigrade.

By the following experiment, Doctor Joule determined the mechanical equivalent of heat. A paddle fitted to a shaft made to revolve by weights so constructed that the exact amount of work done by them could be measured, was placed in a cylindrical vessel containing a definite amount of water at a known temperature. As the paddle revolved the water was agitated and the temperature was found to rise. The energy of the weights had been converted first into motion of the paddle, then into heat in the water. He determined that when mechanical energy is converted into heat the amount of heat produced is proportional to the mechanical energy expended, and specificially, that one calorie represents 424 kilogrammeters of energy. The mechanical equivalent of heat then, or as it is called Joule's equivalent, is 424 kilogrammeters. In the English system the same equivalent is 772.55 foot-pounds, or one B.t.u., later definitely fixed as 778 foot-pounds.

Since the amount of heat required to raise the temperature of one pound of water one degree Fahrenheit, has been made the standard unit by which other quantities of heat are measured, the latent and specific heats above defined are expressed in B.t.u. The specific heat of water is unity.

Since the amount of heat required to raise the temperature of one pound of ice one degree is one-half that of water, the specific heat of water in the solid state is one-half B.t.u., or simply 0.5. Similarly the latent heat of fusion of water is 144,* the latent heat of vaporization is 966.1, and the specific heat of steam, according to whether it is taken at constant pressure or constant volume is 0.480 and 0.346, respectively.

It will be noted that the specific heat of constant pressure is somewhat greater than the specific heat of constant volume. In determining the latter, the gas is not allowed to expand, in other words, it is maintained at a "constant volume." In determining the former, the volume is allowed to increase with the addition of heat just sufficiently to maintain a "constant pressure." The work done by the gas in expanding is equivalent to the excess of the amount of heat supplied in the case of constant pressure, over that required to produce the same rise in temperature at constant volume.

Under a given pressure there is for every substance, a definite and fixed temperature at which that substance will change from one of its three states, the solid, the liquid, or the gaseous, to another, and at each change that substance absorbs or liberates an amount of heat, which, though varying slightly at different temperatures, is more or less a constant and characteristic of that particular change of state of that particular substance. So constant is the temperature at which these changes of state take place that the simple determination of the boiling point under atmospheric pressure, of some of the more common liquids such as alcohol, water, ammonia, etc., is sufficient to establish their identities. At atmospheric pressure alcohol boils at 173 degrees Fahrenheit, water at 212 degrees Fahrenheit and ammonia at 28½ degrees Fahrenheit. Except for the question of the facility of conducting the experiments, the freezing points of the liquids in question might just as well be employed to determine their composition. Absolute alcohol, for example, freezes at 202 degrees Fahrenheit and water at 32 degrees Fahrenheit. In general, the addition of a foreign substance capable of being dissolved in either of these liquids has the effect of lowering the freezing point and raising the boiling point.

Similarly, the amount of heat absorbed or liberated when a fixed quantity of one of the above liquids changes state, is so nearly a constant that it could be employed to establish the identity of the liquid were it not for the difficulty of determining the exact amount of heat involved. A pound of water, for example, absorbs 144 B.t.u. in changing from the solid to the liquid state, and 965.7 B.t.u. in changing from the liquid to the gaseous state. Similarly, in changing from the liquid to the gaseous state a pound of anhydrous ammonia absorbs 555 B.t.u.

It has been stated above that there is always a tendency for heat to flow from one body to another wherever there is a difference in temperature. For the present purpose, it may be generally stated that the rate at which the passage of heat takes place is directly proportional to the difference in temperature, and in-

*At the New York meeting of the American Society of Mechanical Engineers, a committee appointed by that society to suggest a standard tonnage basis for refrigeration proposed as a unit for measuring cooling effect, the equivalent of the heat required to melt one pound of ice, i.e., 144 B.t.u. The unit for a ton of 2000 pounds of ice-melting capacity was then fixed at 288,000 B.t.u., which, since the rating is always expressed in tons per 24 hours, makes a ton duty equivalent to the rate of 12,000 B.t.u. per hour, or 200 B.t.u. per minute.

versely proportional to the amount of resistance offered to its passage by interposed substances. The flow of heat is analogous to the flow of electricity in an electrical conductor which is inversely proportional to the voltage as expressed in Ohm's law

$$C = \frac{E}{R}$$

where C is the current in amperes, E the voltage and R the resistance in ohms. The flow of heat may also be compared to the flow of water through a pipe, which is also proportional to the difference in pressure and inversely proportional to the friction.

Passage of heat may take place by convection, conduction, or radiation, and in the general case, by all three methods simultaneously, so that the mathematical expression for the total heat transfer between two bodies of different temperatures becomes somewhat complex. Fortunately, in the greater number of engineering problems the amount of heat transmitted by conduction is so far in excess of that transmitted by radiation and convection that the last two factors are ignored entirely or are introduced in terms of conduction.

Where the refrigerating effect is due to the direct passage of heat from one substance to another, it is almost axiomatic that the cooling of one can take place only with the equivalent heating of the other.

The most common examples furnished by nature, of processes by which the refrigerating of one body is accomplished by a corresponding heating of another, are the changing of water into ice and its subsequent melting to form water. In the former process, heat passes from the water to the air, the water being refrigerated and the air heated. Conversely in the latter process, heat passes from the air to the ice, the air being refrigerated and the water heated. Both these processes ordinarily take place under atmospheric pressure at 32 degrees Fahrenheit.

Among others of this class of examples, i.e., that in which the refrigerating effect produces change from the liquid to the solid state, may be cited the congealing and subsequent melting of mercury at 39 degrees Fahrenheit, and that of cast iron at about 2000 degrees Fahrenheit, or in fact that of any fusible substance at its temperature of fusion. In the foregoing examples, absorption of heat, or refrigeration, involves the latest heat of fusion of the substances, water, mercury and iron, in question. Another means of bringing about the absorption of heat or refrigeration is by the evaporation of liquids. This involves the latent heat of vaporization, and the fact that the latent heat of vaporization of a substance is greater than the latent heat of fusion is one reason why the former method is the more commonly employed in connection with artificial refrigerating systems.

Probably the most common example furnished by nature, of refrigeration produced by the evaporation of a liquid, is the cooling effect of summer showers, in which the evaporation of a part of the water precipitated cools the dry, hot air which absorbs it. Another well known cooling effect is encountered when we sit in a draft after perspiring freely. The effect of the motion of the air is simply to displace the stratum of warm, saturated air lying next the skin by cool dry air which, in absorbing more moisture produces a refrigerating effect, which often actually lowers the temperature of the body and produces such an unbalancing of its functions as to cause so called colds or even pneumonia. Among less common examples may be cited the methods of cooling drinking water sometimes employed on shipboard, i.e., by exposing it to the wind in porous tile vessels, the evaporation of a part of the water through the walls of which refrigerates the portion remaining in the vessel. In India ice is actually frozen by the rapid evaporation of water exposed in shallow earthen trays to the clean, dry night air.

Evaporation can take place only with absorption of a fixed quantity of heat. Conversely, absorption of heat, or refrigeration always occurs when a substance is evaporated, whether the evaporation takes place rapidly at the boiling point or slowly at a temperature far below its boiling point. Since no two simple substances boil under the same conditions of temperature, it follows that it may be possible to produce refrigeration either at a given temperature by the evaporation of different substances at different pressures, or within certain limits, to produce refrigeration at quite widely different temperatures by the evaporation of the same substance at different pressures.

While the availability of the latent heat of vaporization of water at 32 degrees Fahrenheit requires the usually prohibitive vacuum of 29.76 inches of mercury, the fact that the latent heat of fusion of water is available at 32 degrees Fahrenheit under atmospheric pressure, allows artificial ice to become as important a factor in our general scheme of domestic and commercial economy as natural ice, the freezing and subsequent melting of which in our lakes and rivers protects both animal and vegetable life through the tempering of extreme temperatures in natural economy.

Much of the popular misconception of the art of refrigeration has arisen through our proneness to group temperatures into such technically meaningless classes as "warm," "hot," "cool" and "cold," according to their apparent relation to the widely varying temperatures of our surroundings, which we erroneously come to look upon as a kind of variable zero from which all other temperatures should be measured. This in turn gives rise to the erroneous notion that a substance is capable of heating or refrigerating other substances according to whether it appears hot or cold to the touch.

If a person places his hand on a body much lower in temperature than his body, he describes it as being cold. If, in the other case, it has a temperature higher than that of his body, he describes it as being hot. Since heat and cold are relative terms arising from comparison with normal temperatures, a temperature described as being hot in winter might be regarded as being cold in summer. The fact that a body is already cold does not prevent its being made still colder by the further removal of heat. The coldest substances known are still possessed of a large quantity of heat, only part of which can be abstracted by any known method. Could all of this heat be removed from a substance, the resulting temperature would be absolute zero, or about 46 degrees below our present Fahrenheit zero. At this point all chemical action would cease, and neither animal nor vegetable life could exist.

Since refrigeration, which occurs whenever there is a flow of heat from a relatively warmer to a relatively cooler body, may take place at any temperature regardless of whether it is above or below that of our surroundings, the melting of iron in a blast furnace may be said to refrigerate the contents of a blast furnace just as truly as the melting of ice does the contents of a refrigerator.

In general the most desirable working medium is that substance which has either its latent heat of vaporization or latent heat of fusion available under not too abnormal conditions. The melting point of ice being 32 degrees Fahrenheit under atmospheric pressure, the latent heat of fusion of water is available at a most convenient temperature and that substance has accordingly found an almost unlimited application in the arts. But, while evaporation of water in the tubes of a water-tube boiler refrigerates the furnace gases, in almost the same way as the evaporation of other liquids (so called refrigerating media), do the air surrounding the similar pipe coils in direct-expansion refrigerating systems, the fact that the latent heat of vaporization of steam is not generally available at less than 212 degrees Fahrenheit under atmospheric pressure, has up to the present time, prevented the extensive use of that medium in connection with what are commonly termed "refrigerating systems."

Using a Sewer for Condensing

Increasing capacity of the McDonald-Road station at Edinburg by installing low-pressure turbines and condensers using water from the sewer for cooling, has reduced the cost of fuel per unit generated 33.4 per cent.

In a paper recently presented to the Incorporated Municipal Electrical Association, at Glasgow, Frank A. Newington, chief electrical engineer of Edinburgh, told how the capacity of that station had been increased and the cost per unit reduced by the use of low-pressure turbines, using the water of a neighboring sewer for condensing purposes. The plant is that at the McDonald-Road station at Edinburgh, and was designed for the use of cooling towers, the installation of which had to be abandoned on account of the fear that the towers would be unsightly and might cause a nuisance by scattering moisture about the neighborhood.

In 1907 it was found that the Leith main sewer, which passed about 180 yards from the station, had an average flow of about 750,000 gallons per hour, which could be utilized for condensing purposes. Four suction pipes, each 18 inches in diameter, and one discharge pipe 26 inches in diameter were laid from the shaft to the station. Straining screens were fitted in the shaft in front of the suction pit and the end of the discharge pipe in the sewer is sealed, so that siphonic action is maintained. There is considerable air in the water, so that two extracting pumps have been provided, one acting upon the air on the suction side of the pump, and the other on the delivery. In addition to the screening in the pit, the water is passed through a Bailey & Jackson rotary strainer, in which the returning water is made to wash away the deposit left by the water as it enters. Four surface condensers of the contra-flow type, each having a cooling surface of 7750 square feet, with Edwards air pumps are used. The temperature of the water in the sewer averages about 60 degrees in the winter and 70 in the summer. As it must be returned to the sewer at not above 90 degrees, the range is not large, and the quantity of circulating water required per pound of steam considerable.

At present only two exhaust-steam turbo-generators have been installed, but there is sufficient steam from the reciprocating engines for two more exhaust turbines, and these will be added as soon as the increase in output requires it. The turbines are of the Rateau type, running at 1250 revolutions per minute, with a guaranteed output of 1200 kilowatts, about 2200 amperes and 560 volts, with 45,600 pounds of steam per hour, at a pressure at the inlet to the turbine not exceeding 14.7 pounds per square inch absolute, and at the exhaust 1.3 pounds absolute—say 27¼ inches vacuum. This output is easily attained in every-day work. Live steam is connected to each turbine through a reducing valve in case the supply of exhaust steam at any time should not be sufficient. The rotor of each turbine has 11 wheels with 265 blades to a wheel. The exhaust-steam piping is arranged so that the steam from the reciprocating set can pass either to the exhaust-steam turbines or direct to two other condensers. Oil separators of the Blake type are placed in the exhaust pipes between the reciprocating engines of the turbine, which extract the greater part of the oil and the feed water is further treated by the Davis-Perrot electrical process to free it from the rest. The water from the air-pump discharge passes into wooden tanks, in which are a number of iron plates spaced about 2 inches apart. A current of electricity is passed through these tanks with the object of precipitating finely divided oxide of iron. The small globules of oil adhere to the oxide of iron and are easily separated from the water. The treated oily water then passes into filters containing gravel and sand, which retain the oil. The current required is one kilowatt-hour per thousand gallons. The makers guarantee that the filtered water will not contain more than 0.1 grain of oil per gallon, and after 12 months' steaming the boilers show hardly a trace of oil. The author concludes his paper as follows:

Cost of Plant.—The condensing plant is sufficient to deal with the steam from reciprocating and exhaust turbines of 11,000 kilowatts.

The capital cost was as follows:

	£	Per Kw. £
Sewer shaft with four 18-inch suction and one 26-inch discharge pipe in roadway	5,600	0.5
Circulating-water exhaust-steam pipework inside the station and oil-extracting plant	6,000	0.5
Rotary water strainer	2,000	0.2
Four condensers circulating and air pumps	11,000	1.0
	£24,600	2.2
Two 1,200-kilowatt turbo-generators with switchboard	13,800	5.7

The economy caused by the exhaust-steam turbines and condensing plant is shown by the following figures, which are for similar periods in 1908 when only reciprocating engines were used without condensation, and in 1910 with exhaust-steam turbines and condensation. In 1908 the price of coal was considerably lower —10d. a ton—than in 1910, but for the purpose of comparison the 1910 price has been taken for both periods. In the costs per unit generated for the 1910 figures, the units used by the condensing plant have been deducted. As only three of the boilers are fitted with superheaters the amount of superheat is quite small:

	1908.	1910.
Duration of test	3 weeks	3 weeks
Date	Jan. 16 to Feb. 6	Jan. 20 to Feb. 9
Units generated	715,491	888,644
Units used by condensing plant	.....	43,045 equals 4.8%
	715,491	845,599
Load factor	22.8%	25.1%
Plant factor	89.6%	76.9%
Pounds of water per unit generated	39 lb.	22.2 lb.
Pounds of water evaporated per pound of coal	6.67 lb.	6.6 lb.
Pounds of coal per unit generated	5.85 lb.	3.9 lb.
Maximum output	6.227 kw.	7,021 kw.

Costs per Unit Generated

			Saving
Fuel	0.251d.	0.167d.	33.4%
Oils and stores	0.009d.	0.004d.	50 %
Water	0.027d.	0.006d.	78 %
Salaries and wages	0.054d.	0.047d.	
Repairs (estimated)	0.057d.	0.057d.	
	0.398d.	0.281d.	30 %

At present at the time of top load in the winter months, three or four reciprocating engines are exhausting direct to the condensers, so the economy will be increased when the other two turbines are installed.

Some engineers seem to think that exhaust-steam turbines are only a passing fashion and will disappear in a few years, but in stations with existing reciprocating engines, either exhaust-steam or mixed-pressure turbines seem the most suitable for extensions, as the combination of reciprocating engine and turbine is as economical as high-pressure turbines and obviates all necessity of scrapping the old sets until these are worn out.

As shown by the figures giving the capital costs, the price of the sewer shaft and pipe work in the roadway comes to £5 per kilowatt. This is considerably less than cooling towers would have cost. In places where a river or other sufficient supply of water is not available for condensation, a main sewer, if near the generating station, is well worth consideration.

On December 31, 1908, the length of the steam railroads of the United States was 232,045.9 miles. Accurate figures for electric railroads are not available, but on approximately the same date the length of the street and interurban railroads was in round figures, 35,000 miles, or about one-seventh the railroad mileage of the country.

Electrical Department

Primer of Electricity

Especially conducted to be of interest and service to the men in charge of the electrical equipment.

Friction Losses of a Dynamo

Besides the losses in the armature core, in the armature winding and at the contacts between the brushes and the commutator due to contact resistance, the rubbing of the brushes on the commutator causes a loss due to friction, the turning of the shaft in its bearings causes a similar loss and there is a slight loss due to the rapid motion of the armature surfaces through the air; this latter loss is called "windage," because the energy thus lost is used up in setting the air in motion.

Brush Friction

The friction loss at the brush faces varies with the quality of the carbon in the brush, the condition of the commutator surface, the speed of rotation and the pressure of the brushes against the commutator. It is impracticable to estimate the effect of different conditions of the commutator surface, but the effects of brush quality and pressure and commutator speed are quite regular. The friction loss in watts per square inch of brush contact surface is equal to

$$0.0226 \times \textit{brush pressure per square inch} \times \textit{velocity} \times k,$$

the velocity being that of the commutator surface in feet per minute and the symbol k representing the coefficient of friction. This coefficient depends on the quality of the brush and the condition of the commutator surface. The velocity of the commutator surface in feet per minute is, of course, equal to 3.1416 $\times$ diameter in inches $\times$ revolutions per minute $\div$ 12, the division by 12 being made to reduce inches to feet.

For commutators in reasonably good condition and brushes of the hard and soft grades ordinarily used in this country, the chart, Fig. 57, gives the friction loss that will usually occur at brush faces. For example, suppose a commutator 6 inches in diameter runs at 900 revolutions per minute and soft carbon brushes are used. The diameter $\times$ speed $= 6 \times 900 = 5400$. If the spring pressure on the brushes is 1½ pounds per square inch of contact area, the friction loss will be 21½ watts per square inch of contact area.

The loss is ascertained from the chart by starting at the point on the side scale that would be marked 5400 if there were room to mark every division of the scale, tracing along this line until the diagonal line marked "Soft Carbon 1½ Lbs. Pressure" is reached; then tracing straight up or down from this point to either of the horizontal scales. Each division of the horizontal scales represents one watt, and the diagonal line for soft carbon at 1½ pounds pressure crosses the 5400 horizontal line about half way between the vertical lines corresponding to 21 and 22 watts per square inch; hence, the result is 21½ watts per square inch.

Now suppose the brush pressure were increased to 2 pounds per square inch. Starting at 5400 in the vertical scale again, follow that line until the diagonal line for soft carbon at 2 pounds pressure is reached. This falls between the

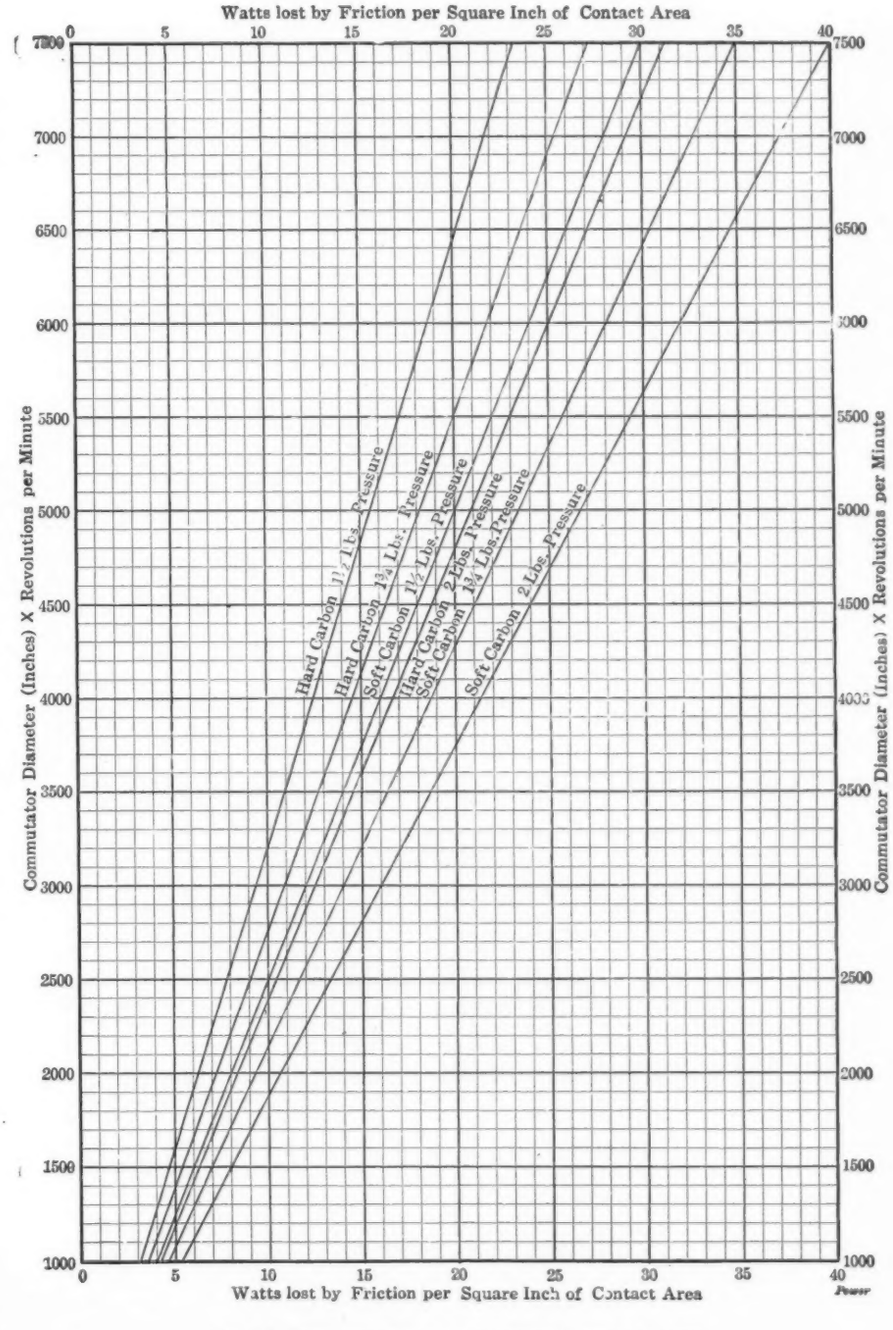

Watts lost by Friction per Square Inch of Contact Area
Commutator Diameter (Inches) X Revolutions per Minute
Hard Carbon 1½ Lbs. Pressure
Hard Carbon 1¾ Lbs. Pressure
Soft Carbon 1½ Lbs. Pressure
Hard Carbon 2 Lbs. Pressure
Soft Carbon 1¾ Lbs. Pressure
Soft Carbon 2 Lbs. Pressure

FIG. 57. FRICTION LOSS AT CARBON BRUSH FACES

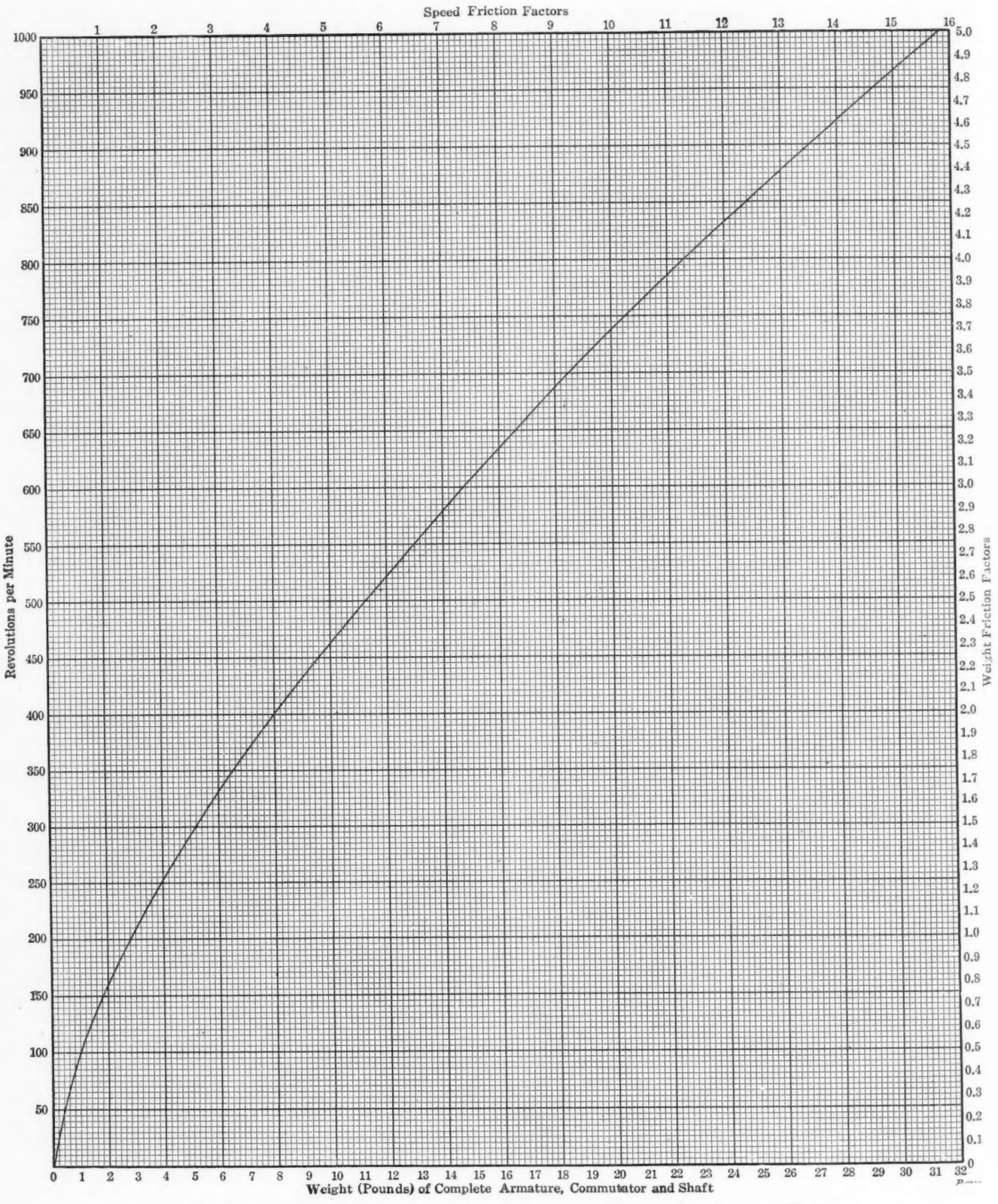

Speed Friction Factors
Revolutions per Minute
Weight Friction Factors
Weight (Pounds) of Complete Armature, Commutator and Shaft

FIG. 58. CHART GIVING APPROXIMATE LOSS BY ARMATURE BEARING FRICTION AND WINDAGE

vertical lines corresponding to 28 and 29 watts, and is about three-quarters of the distance from the one to the other; the friction loss, therefore, would be about 28¾ watts per square inch of contact area.

The student will find it interesting to compare the results obtained with hard and soft carbon, as well as the differences caused by changing the brush pressure on the commutator. For example, if a commutator 14¾ inches in diameter and running at 400 revolutions per minute were worked with soft carbon brushes at 1¾ pounds per square inch pressure, the friction loss would be 27½ watts per square inch of contact area. Now if hard carbon brushes were substituted, the speed and brush pressure remaining the same, the friction loss would fall to 21½ watts per square inch of contact.

The question of using hard or soft brushes, however, cannot be decided merely from the comparative friction losses; it is governed by much more important considerations, which will be explained in a future lesson.

It should be noted and remembered that all of the quantities discussed in

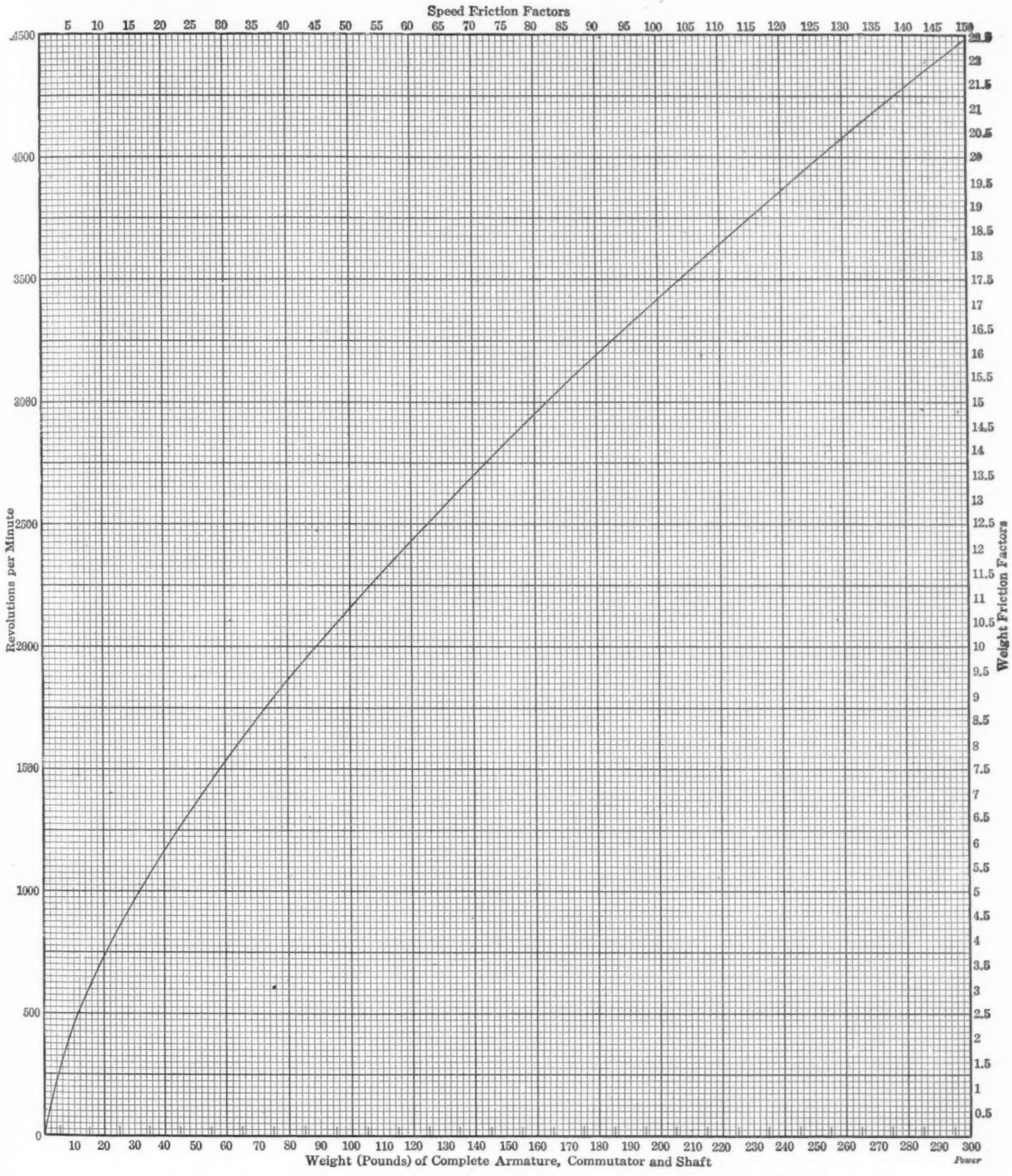


FIG. 59. CHART GIVING APPROXIMATE LOSS BY ARMATURE BEARING FRICTION AND WINDAGE

this lesson and the previous one, excepting the voltage drop at the brush contacts and the velocity of the commutator surface, relate to one square inch of contact area; thus, the contact resistance, the watts lost by that resistance, the brush pressure on the commutator and the watts lost by friction are all given *per square inch of contact area.* This means that the total watts lost by resistance are equal to the watts per square inch multiplied by the total area of all the brush faces on the machine, and the total loss by friction is, similarly, equal to the watts lost per square inch multiplied by the total area of all the brush faces.

Resistance varies in the opposite direction, and the total resistance of all brush faces, therefore, is equal to 4 $\times$ resistance per square inch $\div$ total area of all brush faces, because one-half of the brush faces are in series with the other half. There is no need to bother with contact resistance, however, because it is only the voltage drop and the loss in watts that are of practical importance, and these can be estimated from the charts given in the preceding lesson.

In practical operation, the only feature that the dynamo attendant can control is the pressure of the brushes against the commutator, and he should understand very clearly, therefore, what is meant by

pressure per square inch. It is the total spring pressure on one brush, divided by the area of the contact surface of that brush. It is seldom necessary to carry this pressure beyond two pounds per square inch of brush face and seldom practical to reduce it much below 1½ pounds per square inch. The practical worker, however, should understand all of the underlying principles of the apparatus in his charge, even though he may not control the application of them.

Journal Friction

At the journal speeds commonly employed with dynamos and motors, the loss in the shaft bearings is proportional to the 1.5 power of the velocity of the bearing surface and to the pressure per square inch of bearing surface due to the weight of the armature, commutator and shaft. The loss due to windage is proportional to the cube of the velocity of the armature periphery. The proportionalities depend on the character of lubrication (for the bearings) and the character of the armature surface (for the windage). It is, therefore, impractical to attempt any workable formulas that would give accurate results for all cases. If the bearings are well lubricated and the length of bearing is not less than three times its diameter, and if the armature has not an unusually uneven surface or high velocity (beyond 3800 to 4000 feet per minute), the loss by bearing friction and armature windage will not be very far different from the result obtained from Figs. 58 and 59. These charts are plotted from a formula which is based on the assumption that the combined friction and windage loss is proportional to the cube of the square root of the speed and to the square of the cube root of the weight of the armature, commutator and shaft. This formula is as follows:

$$\frac{\sqrt{S^3}\,\sqrt[3]{W^2}}{4000} = watts$$

lost by bearing friction and armature windage. In this formula, S is the speed in revolutions per minute and W is the weight of the armature, commutator and shaft, complete.

The charts serve to give both the speed and weight factors of the friction loss. They are used as follows: Find the weight in the scale at the bottom of the chart and follow a straight line from that point up to the curve; from the point where the vertical line strikes the curve, trace horizontally to the right-hand vertical scale, where a number will be found, either directly or by reference to the numbers immediately below and above the point in the scale. This number is set down. Then find the speed in the left-hand vertical scale and follow a straight horizontal line from that point to the curve; from the point where you strike the curve, trace a vertical line up to the scale at the top of the chart; the number at the edge of the chart is the "speed factor," and this multiplied by the number first found gives the approximate loss in watts.

Example I. An armature weighing 22 pounds runs at 850 revolutions per minute. What is the approximate friction loss?

At the bottom of Fig. 58, find the number 22 and trace straight up to the curve; from the point at which the curve crosses the 22 line, trace over to the right-hand scale. The point at which the scale is reached corresponds to 3.925, being just one division above 3.9. Now find 850 in the scale of speeds at the left-hand edge of the chart, and trace that line until it strikes the curve; then trace up to the top scale, where the number 12.4 would be found if every scale division were marked. The weight factor was 3.925, and the product of $3.925 \times 12.4 = 48.67$ watts.

Example II. An armature weighing 144 pounds runs at 1125 revolutions per minute; what is the approximate friction loss?

Both the speed and the weight are beyond the range of Fig. 58, so the other chart must be used. Tracing from 144 in the bottom scale up to the curve and thence across to the right-hand scale gives 13.75 for the weight factor. Tracing from 1125 revolutions (in the left-hand scale) across to the curve and thence up to the top scale gives 19 for the speed factor. The loss, therefore, is about

$$13.75 \times 19 = 261.25 \text{ watts.}$$

Example III. An armature weighs 14 pounds and runs at 1800 revolutions per minute; about what is the friction loss?

In this case, the weight factor must be taken from Fig. 58 and the speed factor from Fig. 59. Tracing from 14 in the bottom scale of Fig. 58 up to the curve and thence over to the right-hand scale gives 2.9 for the weight factor, and tracing from 1800 in the left-hand scale of Fig. 59 over to the curve and thence up to the top scale gives 38 for the speed factor. The approximate loss, therefore, is

$$2.9 \times 38 = 110.2 \text{ watts.}$$

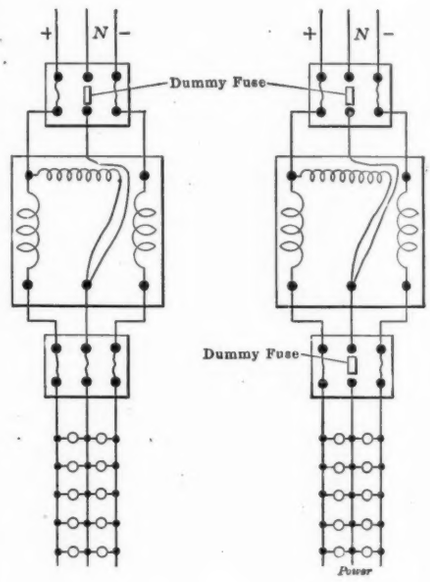
As the results obtained from Figs. 58 and 59 are only approximate, it is unnecessary to carry them out to decimal places. The result in the first example would be called 49 watts, that in the second example 261 watts and that in the last example 110 watts.

As the last example demonstrated, cases will frequently occur in which one chart must be used for the weight factor and the other one for the speed factor; for this reason the two charts have been plotted so that the values are interchangeable.

While the weights and speeds covered by the bottom and side scales of Fig. 58 are also included in the scales of Fig. 59, it is much better to use Fig. 58 for all the values within its range and to use Fig. 59 only for weights and speeds not contained in the scales of Fig. 58.

Cheating the Electric Meter

Referring to Mr. Howard's article on this subject in the June 14 number of Power, I would like to point out that Mr. Howard is mistaken in thinking that the removal of the main neutral fuse, as in Fig. 3, will prevent the meter from registering. The potential coil of the meter will receive practically normal voltage, and the meter will therefore record about as accurately as if the fuse were not removed, because the coil remains in parallel with the lamps between the + and the neutral wires. In order to prevent the meter from working, both of the neutral fuses would have to be removed, as shown in the diagram sent with this letter.



Mr. Howard's Fig. 3 — Mr. Percy's Diagram

P. C. Percy.

San Francisco, Cal.

In Mr. Howard's article on "Cheating the Electric Meter" he says that the meter connected as in Fig. 3 will not register, and that he has "had several cases of this kind." I don't believe he investigated these "cases" very closely; if he had he would have found that current will flow in the potential winding of the meter and it will record normally, if the load is balanced, because the winding gets half of the total + to − voltage.

W. C. Drake.

Terrell, Texas.

Gas Power Department

A Train Load of Gas Engine

The accompanying photograph shows a train load consisting of a single gas-engine blowing unit, recently shipped to the Lake Superior Iron and Steel Corporation at Sault Ste. Marie, Canada. The gas engine is of the twin-tandem type with cylinders 34x48 inches, to work on the four-stroke cycle. It was built by the Allis-Chalmers Company and conforms to the company's standard practice in all respects. This is the third blowing unit that has been shipped to the Lake Superior Corporation, and four engines exactly like this one have been supplied for driving 2300-volt three-phase alternators, which supply current at 25 cycles to motors about the steel mills. Each of these units weighed about 1,000,000 pounds and required twelve flat cars for its transportation.

Everything worth while in the gas engine and producer industry will be treated here in a way that can be of use to practical men.

Surplus Power Available in Steel Works*

By Richard Bechtel

A blast-furnace plant having an output of 250 tons of pig iron per 24 hours requires about 10 tons of coke per hour. Of the quantity of heat put into the furnaces by this coke, 60 to 65 per cent. leaves the furnace again in the gas. About 28 per cent. of the heat, or 43 per cent. of the gas leaving the furnace, is used

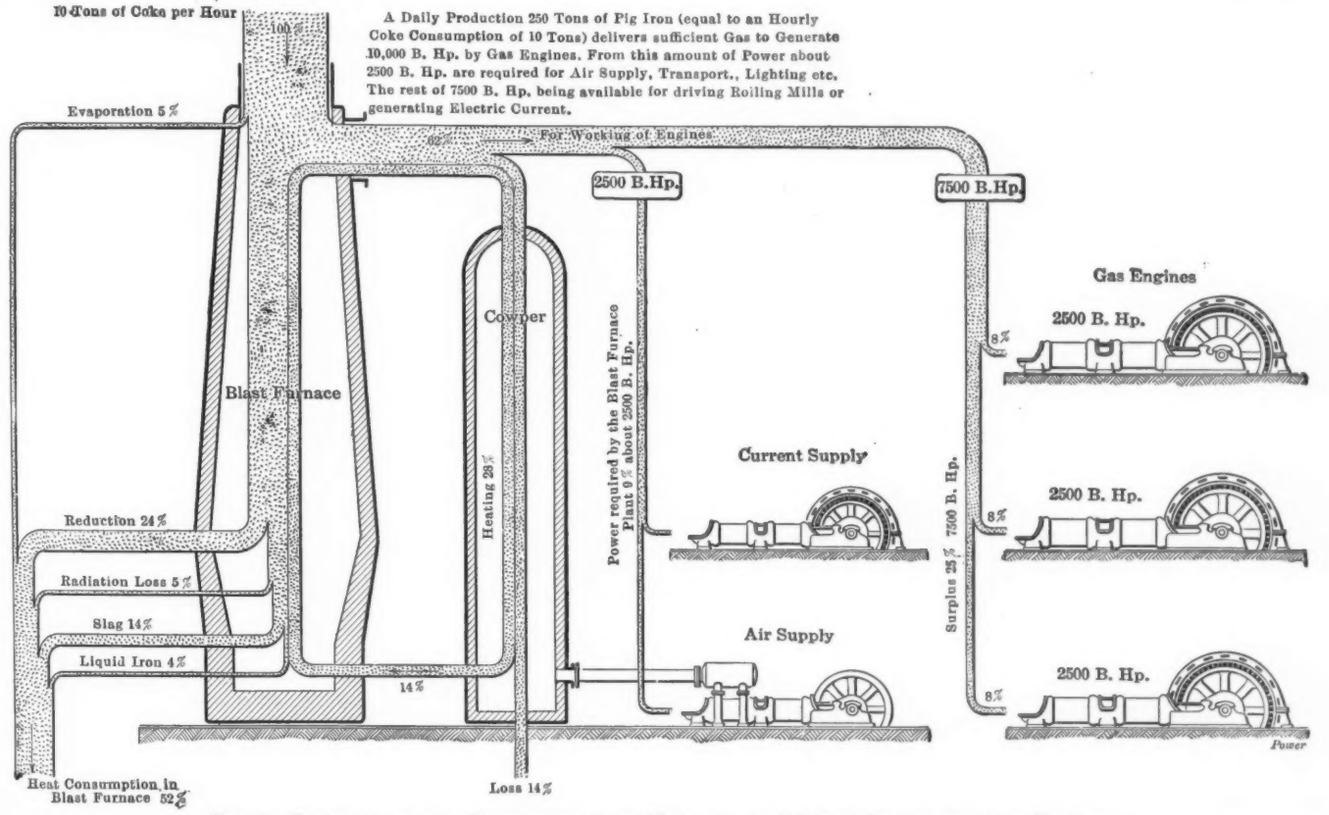
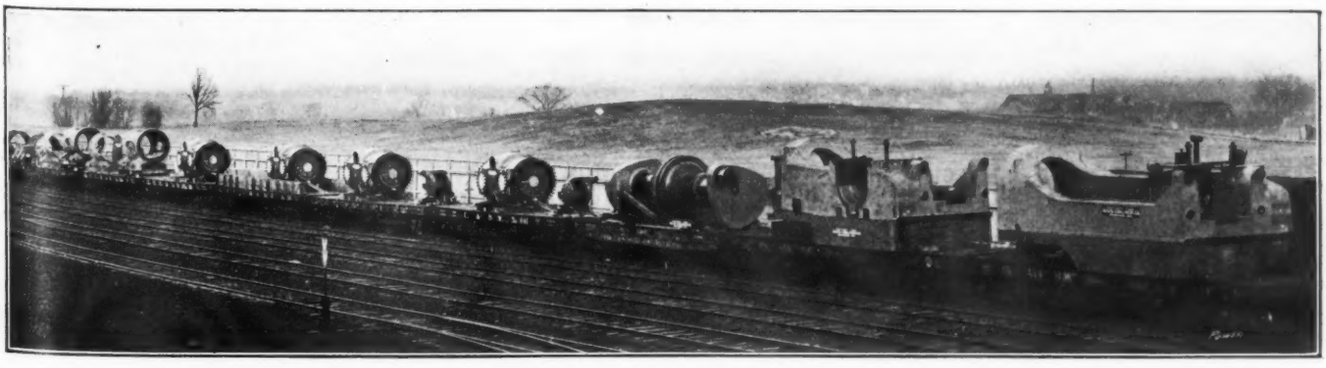

10 Tons of Coke per Hour
100%
A Daily Production 250 Tons of Pig Iron (equal to an Hourly Coke Consumption of 10 Tons) delivers sufficient Gas to Generate 10,000 B. Hp. by Gas Engines. From this amount of Power about 2500 B. Hp. are required for Air Supply, Transport., Lighting etc. The rest of 7500 B. Hp. being available for driving Rolling Mills or generating Electric Current.
Evaporation 5%
62% For Working of Engines
2500 B.Hp.
7500 B.Hp.
Gas Engines
2500 B. Hp.
Cowper
Blast Furnace
Heating 23%
Power required by the Blast Furnace Plant 9% about 2500 B. Hp.
Current Supply
8%
2500 B. Hp.
Reduction 24%
Radiation Loss 5%
Slag 14%
Liquid Iron 4%
Air Supply
Surplus 25% 7500 B. Hp.
14%
8%
2500 B. Hp.
Heat Consumption in Blast Furnace 52%
Loss 14%
Power

Fig. 1. Diagram of the Distribution of Heat in a 250-ton Blast-furnace Plant



A Train Load of Gas Engine

*Extract from a paper read before the Birmingham (England) Association of Mechanical Engineers.

for heating the blast in the stoves, and the rest is available for power purposes. Generally 8 to 10 per cent. of the heat, or 12 to 15 per cent. of the gas, is used for driving the gas-blowing engines and for generating electric current for the hoists, lighting and water supply of the furnaces. The power still remaining—about 24 per cent. of the heat, equal to not less than 7500 brake horsepower generated in gas engines—is available for any other purpose. Fig. 1 illustrates this distribution of heat energy.

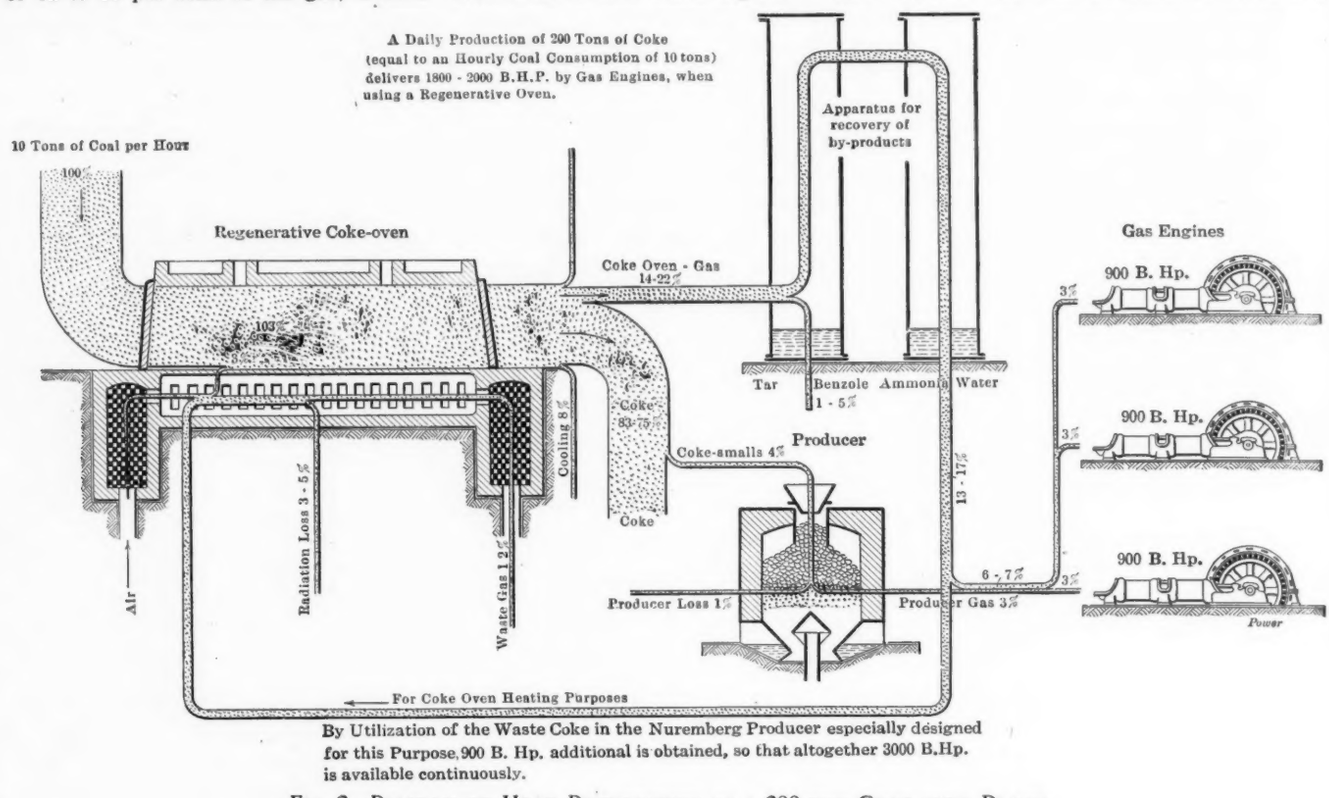


FIG. 2. DIAGRAM OF HEAT DISTRIBUTION IN A 200-TON COKE-OVEN PLANT

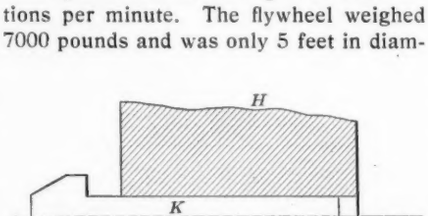
Similar conditions prevail in collieries having uptodate coke-oven plants with by-product recovery and surplus gas. Fig. 2 represents the heat distribution in a coke-oven plant of a production capacity of 200 tons of coke per 24 hours. This quantity is obtained by the consumption of 10 tons of coal per hour, which gives, after deducting all losses, a quantity of gas equal to 1800 to 2100 brake horsepower in gas engines. If the coke ashes are utilized in special producers a further 900 to 1000 brake horsepower can be obtained by gas engines, giving a total of 3000 brake horsepower.

If the gas from the furnaces is burned under boilers about 200 cubic feet of blast-furnace gas of, say, 100 B.t.u. per cubic foot is required per brake horsepower by first-class boilers and steam turbines so long as the plant is new, but for ordinary working conditions ample addition must be made. Professor Bonte states as the gas-consumption figure for gas-heated boilers in coal and iron works, according to reports from many uptodate and best managed works, 22.5 cubic feet to generate one pound of steam. In old boiler plants, with long piping and old-fashioned engines, the consumption is even three or four times higher. Nowadays, to improve the efficiency of steam-engine plants, the exhaust steam from winding engines, hauling and rolling-mill engines, etc., is used for driving exhaust-steam turbines, but with this improvement the economy is quite small in comparison with the economies of gas engines.

CORRESPONDENCE

Keying a Creeping Flywheel

Some months ago I was sent to key the flywheel of an ordinary four-stroke-cycle vertical gas engine, having two 12x12-inch cylinders and running at 325 revolutions per minute. The flywheel weighed 7000 pounds and was only 5 feet in diameter, on account of the high speed at which the engine ran, the weight being obtained by using a very heavy rim 18 inches wide. When I arrived at the plant the engineer had the wheel in place but by mistake had put it on the opposite way to that in which it had been running before. He had no jacks or block and tackle strong enough to lift the wheel, which had made it quite a task to get the wheel in place and promised to make it still harder to take it off again; to make matters worse, the engine was in a very crowded location. It was explained that the wheel had a tendency to shift endwise on the shaft while running in the old position. The hub of the flywheel was 12 inches long, with two keyways. On calipering the keys the faces were found to be practically parallel, as also were the keyways in the shaft and hub. This meant that the keyway in the hub would have to be tapered, but no facilities for making the proper taper were at hand.



KEY AND WEDGE IN FLYWHEEL HUB

Although the wheel was on wrong according to marks on the hub, the keyways in the hub and shaft lined up perfectly; so I decided to try the scheme shown in the illustration. This shows a part section of the hub *H* and the shaft *S* on a line with the side of the key. We had a nearby blacksmith forge a wedge for each keyway, as indicated at *W;* this was made to fit the keyway along the sides, and was filed true at the top and bottom, using the flat side of the wheel rim as a surface plate. The thick end of the wedge butted against the end of the keyway in the shaft, and the key *K* was then fitted as shown. It has run for five months and seems to be a first-class job.

FRANK E. BOOTH.

Toronto, Can.

Readers with Something to Say

Practical information from the man on the job. A letter good enough to print here will be paid for. Ideas, not mere words, wanted.

Right Angled Drives

Two interesting examples of right-angled drives using belt transmission were seen recently by the writer at the plant of the Standard Box Company, Baton Rouge, La. The main shaft from the engine passes across the center of the machine room at right angles to the countershaft driving the machines, which are distributed throughout the length of the room. The two shafts clear by about 2 inches at the point where they cross.

Fig. 1 shows how the connection was made between the two shafts. There are only two pulleys in addition to the driving and driven pulleys, one of these being a transfer pulley and the other an

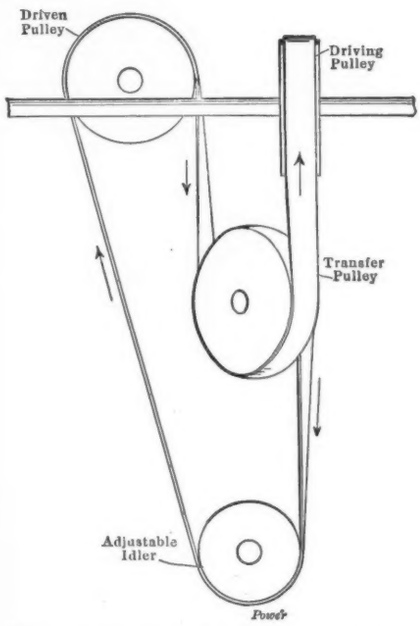


FIG. 1. RIGHT-ANGLED DRIVE WITH MAIN SHAFT CLOSE TO COUNTERSHAFT

idler, which being adjustable, serves also to tighten the belt. A study of the sketch will show that there is practically no tendency to stretch the edges of the belt or to cause friction due to the sliding of the belt on the face of the pulleys, as is the case with the usual quarter-turn drive when the load is heavy. The belt has only one-eighth turn at the two points where the driving strain is greatest, these points being on each side of the transfer pulley between the driving and driven pulleys. The only place where the belt has a quarter turn is on the slack side between the driving pulley and the idler, and as this is on long centers, there is no tendency to stretch the edges of the belt.

One valuable feature of this drive is the fact that the belt turns over in passing from the driven pulley around the transfer pulley and onto the driving pulley, which allows of an equal wear on both sides. This drive has high efficiency, runs perfectly true, and is practically noiseless.

Another novel drive in this same factory is that shown in Fig. 2. In this case it was desired to drive a small ma-

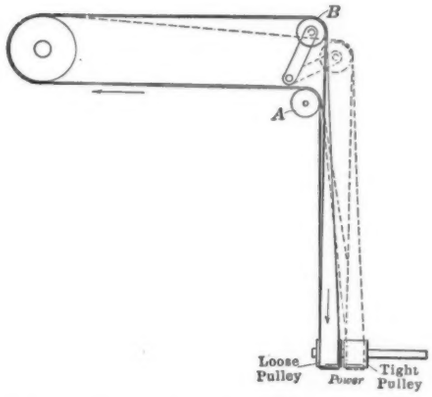


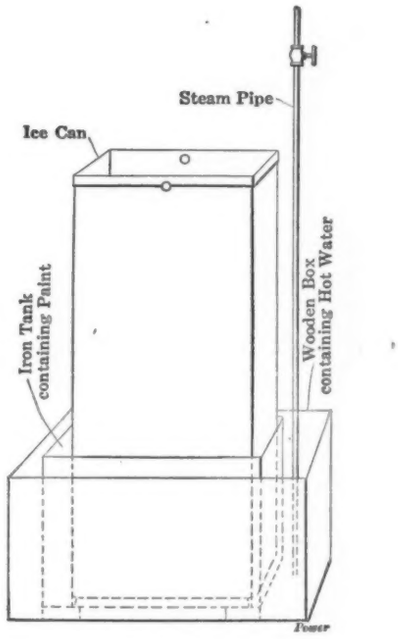
FIG. 2. SIMPLE MEANS OF SHIFTING BELT

chine with tight and loose pulleys, as it was used only occasionally for a few minutes at a time. On account of the limited space available it was found necessary to place it at some distance from the line shaft, and also to set it at right angles to this shaft. It was belted up as shown, *A* and *B* being the guide pulleys, the lower one of which is stationary, and the top one hinged and operated by a lever from the floor, which is not shown in the sketch. When set in the high position, the belt runs on the loose pulley and when thrown to the lower position, as shown by the dotted lines, the belt runs over onto the tight pulley. The belt runs perfectly true in either position. These drives were designed and installed by Mr. Walker, foreman of the above mentioned company.

New York City. S. KIRLIN.

Repairing Ice Cans

As the ice season is now well advanced, and the time for trouble with leaky cans is at hand, I will describe my method of temporarily repairing them. I have made a small wooden box, inside of which is placed an iron tank that will hold the ice cans and extend 10 or 12 inches up the sides. The wooden box is filled with water after the iron tank is



SCHEME FOR DIPPING CANS

in place, and then the iron tank is filled about one-half full of paint. Steam is turned into the wooden box and the water and paint are raised in temperature to nearly 212 degrees. The ice can is then placed in the iron tank containing the hot paint and left there about ten minutes, or until the paint has had time to flow into all the small holes that may be in the can. It is then removed from the tank and the surplus paint is wiped off with a paint brush. The can is now turned upside down, so that the paint will not drain from the leaks, and is left in this position for about three hours, after which the can may be put into service again.

The object of heating the paint in hot water is to prevent fire, also so that the repair can be made indoors. Heating the paint thins it so that it will find its way into the smallest holes or cracks. It is not necessary to paint more than 10 or 12 inches up the sides, as 99 per cent. of the leaks occur at the bottom.

I have repaired a great many cans in

this manner and seldom have them come back for repairs during the season.

W. H. BEISLEY.

Natchez, Miss.

Damper Regulators and Upright Water Tube Boilers

Will some of the readers of POWER relate their experience with automatic damper regulators, stating the saving in coal bills when using the best types. I should also like to get some ideas as to homemade regulators.

A few pointers upon the care and operation of upright water-tube boilers would be appreciated, particularly as to the advisability of using asbestos-packed plug cocks for the blowoff on this type of boiler.

R. G. PARKER.

Detroit, Mich.

Piping Layout for Criticism

The accompanying diagram shows the layout of piping which is being installed in the plant in which I am employed. I should like the opinion of the readers of POWER as to its embodiments of good design.

The point I wish to bring out is this: *Is it a safe system to use?* I claim that the back-pressure valve is located in a dangerous position, having been taught that a back-pressure valve assumes the same relation to an engine as a safety valve does to a boiler. If so, then this is not a safe plan, as there are two valves between the engine and the back-pressure valve.

Again, if the engine is shut down with from two to five pounds pressure on the system with the bleeder open on the exhaust pipe, steam is being lost all the time, and if the bleeder is closed the exhaust line will fill with water of condensation, a condition that will cause trouble when starting up. If one of the valves on the exhaust should be closed and not opened again before starting up, more trouble would result.

I believe it would be much safer to place the back-pressure valve at the point marked *A* and a check valve at *B*, which would then keep the back pressure from the engines when not running.

D. L. TEMPLE.

Olathe, Kan.

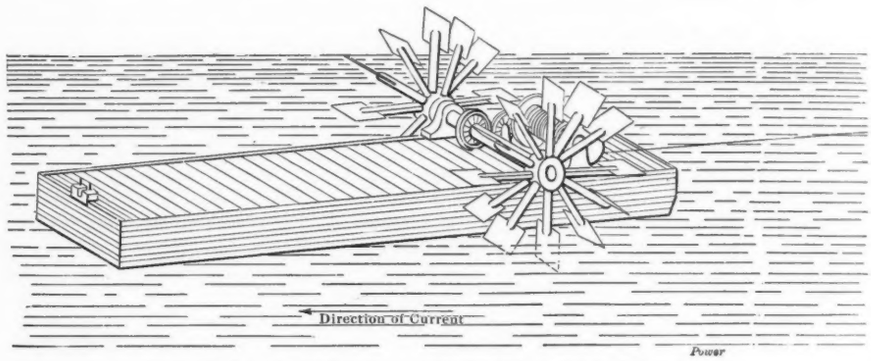
An Unique Application of Power

In a certain river in New England there is a high-water period in the spring when a fair sized ocean steamer could easily manœuver. At the place in question there is 22 feet fall per mile, which causes a rapid current.

Some years ago a good old Yankee wanted to transport some material to an island located in the center of the river at a point where the river was about two-thirds of a mile wide and the island was about seven-eighths of a mile up stream. He had no power except that which nature was producing, and by means of this and a wire cable about ¼ inch in diameter, one end of which was attached to a tree on the island, the other fastened to a reel on board the flat boat, which in turn was connected by gears to a shaft that carried paddle-wheels on each side of the boat, he accomplished his task. After the boat was loaded, the paddlewheels were connected to the reel, which was slowly revolved by the action of the current and commenced to reel up the wire cable, at the same time drawing the boat and its cargo up to the island. The accompanying sketch illustrates the scheme used.

I have seen water put to many uses, but have never run across just this form of hydraulic power. It is easy enough to figure how a boat could be made to pull itself up stream by means of a wire and reel properly reduced by gears, but theory and practice do not always agree.

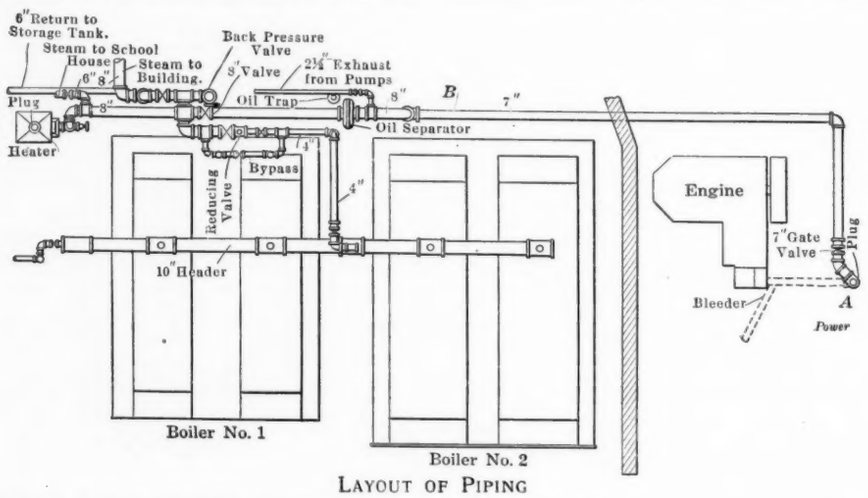
Brooklyn, N. Y. G. C. ABBE.



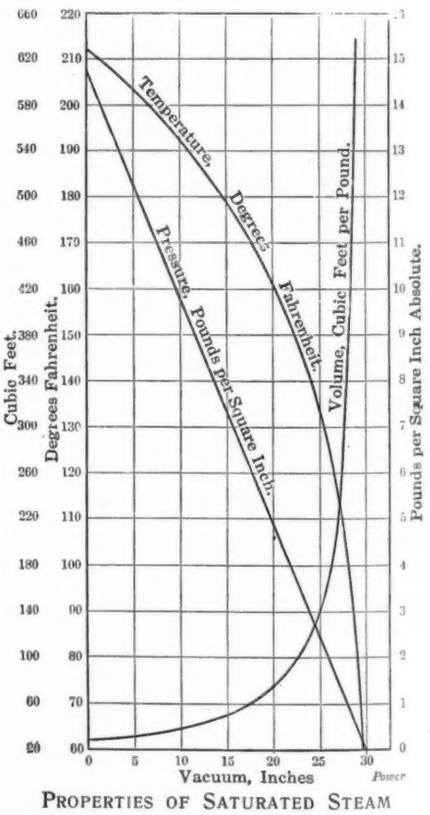
BOAT PROPELLED BY ACTION OF CURRENT

Some Properties of Saturated Steam

The accompanying set of curves shows the relation between vacuum, in inches of mercury, and volume, temperature and pressure for saturated steam. They should prove useful to all engineers who may have occasion to solve problems involving these quantities.



LAYOUT OF PIPING



PROPERTIES OF SATURATED STEAM

W. VINCENT TREEBY.

London, England.

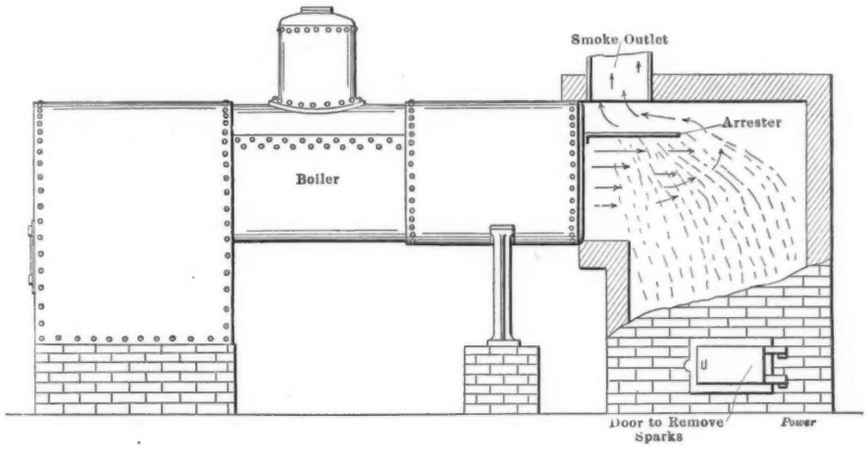
Spark Arrester

Some time ago the question was asked in the columns of POWER as to the best means of preventing sparks from spreading when burning tanbark.

I have never burned tanbark, but have burned hay, straw, sawdust and shavings, in connection with which I have used several spark arresters now on the market, and have put screens in the smoke box and at the top of the stack, only to have them clog up and shut off the draft.

The accompanying sketch shows the means I finally employed and which proved to be the best I had ever used.

There was a 60-foot stack and before the arrester was installed the sparks



SPARK ARRESTER IN PLACE

usually blew nearly one-quarter mile to a neighbor's building. After the arrester was installed, however, I never saw a spark go more than twenty feet from the stack. The space between the arrester and the vertical wall should be greater than that between the arrester and the top of the smoke box.

I. SAWYER.

Hartsdale, N. Y.

An Emergency Piston

Some time ago a bad knock was noticed in the first-stage cylinder of a two-stage air compressor. Upon investigation the piston was found to be badly cracked so as to necessitate another piston being installed.

The machine was needed badly and the repair shop was ransacked for another piston. The nearest that could be found was one an inch too small. This was upset on the edge and babbitt poured around it and then turned to the right size. No rings of any kind were used.

The machine was started inside of 24 hours and gave good satisfaction until a new piston could be obtained.

G. B. LONGSTREET.

Lowell, Mass.

Unusual Boiler Behavior

A strange condition presented itself in our boiler room about four years ago, which can now be told, as the boilers are still in first-class condition and the principals of the incident are working elsewhere.

It was on a Monday morning, and nothing unusual was observed before starting time, there being 80 pounds on the steam gages and the water was well up in the glasses. The load usually came on in the course of five minutes, and the two boilers handled it easily. Both furnaces contained a bright fire and the engines were started as usual, but the pressure dropped unusually fast and the water in No. 2 boiler fluctuated violently and evaporated so fast that it was necessary to keep the pump going at a high speed. On the contrary, the water in No. 1 boiler was very inactive, notwithstanding the fact that there was just as hot a fire under it. When looking at the fire I observed water sizzling from the girth seam over the bridgewall. Things looked alarming, so I gave the safety valve of the inactive boiler a gentle pull to see if it were in order; this immediately started action within the boiler, as indicated by the water in the gage glass fluctuating violently. The gage pressure now rose with surprising rapidity and we had to shut off the blowers to keep the safety valve from popping.

The following is my explanation of the incident: The firebox of No. 1 boiler had been repaired the Saturday and Sunday previous, No. 1 being cut out on Friday night and cooled down by changing the water. The other fire was allowed to go out on Saturday night, and there being no pressure on either boiler on Sunday, they were connected together.

At 5 a.m., Monday morning, the watchman fired up in an easy but dangerous way; he wheeled in about half the usual quantity of slab-wood and started a fire in No. 2 boiler, the one containing the hot water, and when the gages indicated about 40 pounds pressure, which was enough to operate his blowers, he transferred a few shovels of hot coal to the other firebox. In a short time he had a good fire in No. 1 boiler which contained cold water with a film of air on top of it, and 40 pounds pressure on top of that. The top of the boiler was cold and contracted, causing the girth seam to leak. The water was absorbing enormous quantities of heat, with pressure on top preventing ebullition and circulation, and I probably pulled the safety-valve chain at the right time, which started the boiler into action and gave up its accumulated energy to the engines.

CHARLES HAEUSSER.

Albany, N. Y.

Oil Fuel in the British Navy

At present the question of liquid fuel for the British navy is assuming undue prominence. The average man is an earnest student of the daily press, and it should be noted that as there is quite a boom in oil shares, there emanate from interested quarters pointed paragraphs and selected statistics tending to show that the authorities are remiss in their conception of the determining circumstances. If we review the facts, as they must appear to men whose mental attitudes are not obsessed by speculative issues, we may find that the Admiralty have not been lacking in decisive action.

In the first place we must note the admitted advantages of oil fuel over coal when used in steamships. Briefly these are:

1. Weight for weight, it occupies less space than coal.
2. When efficiently used it has about double the calorific value of ordinary coal, weight for weight.
3. Its use involves a considerable saving in stoking.
4. Saving in bunker capacity.
5. It is subject to easy control.

It does not require any very extensive study to grasp these facts, and it is quite reasonable to assume that during the time which the British Admiralty have been experimenting with liquid fuel, they have had ample opportunity of weighing the importance of these advantages. In 1902, after several years of tentative experimental work, preliminary trials fully established the claims of oil and much headway was made in determining the best type of furnace for its use. As a result the authorities came to the conclusion that ten tons of oil were about the equivalent of thirteen tons of best Welsh coal, but it must be noted that at the time they were paying fifty shillings (approximately $12.50) per ton for oil whereas they were able to obtain coal at from sixteen to seventeen shillings (approximately $4) per ton.

At the meeting of the "Royal Commission on Coal Supplies" the following question was put to Dr. Boverton Redwood, the home-office adviser on petroleum: "Do you think there is any likelihood of petroleum supplanting coal in the navy?" His reply is interesting as it contains the gist of the question of oil versus coal for British warships:

"I think that the likeliest form in which petroleum could be employed is as a source of power for the small engines that form part of the equipment of a modern warship where it would be used as an agent in an internal-combustion engine. I do not know where we are going to get adequate supplies for driving the main screws. If the existing output of petroleum in the world were doubled it would only be equivalent to about 5 per cent. of the present coal consumption."

The following table gives the world's production of coal and oil for the years 1901, 1905 and 1909.

	Coal Production, Million Tons.	Oil-field Production, Million Tons.
1901	798	22
1905	940	28½
1909	1100	40

Even on the basis that oil fuel possesses twice the calorific value of coal we find that in 1909 its equivalent weight only amounted to 7.2 per cent. There are many other considerations to be taken into account in addition to that of calorific value. Principal among these, for the British people, is the fact that oil fuel is almost entirely a foreign product, and the following table gives the estimated production of the leading oil-producing countries in 1901 and 1907:

	Per Cent. 1901.	Per Cent. 1909.
United States.....	42.25	64
Russia	51.0	22
Galicia	2.05	4.5
Roumania	88.0	3.0
Mexico	....	1.25
British Empire.....	3.15	5.25

Of the 5.25 per cent. credited to the British Empire in 1909 it must be noted that India claims 2 per cent., Borneo about 3 per cent., Canada about 0.20 per cent., Scotland and other places about 0.05 per cent. Unquestionably there are other great potential oil resources in other parts of the British Empire, notably in Egypt and India, and it might appear quite a simple matter to provide oil stations or bases for the fleet in the same manner as is already done in the case of coal, but many reasons dictate that the source of power of the fleet should be placed outside the region of speculative issues.

R. H. COULSON.

Wigan, England.

Hints to Beginners

In handling boilers, as well as engines, we will do well to keep in mind the following: First, safety; second, continuous operation; third, economy. *Paste that in your hat.* It has helped many an engineer to keep on the right track. Many engineers do their own firing and cleaning, which requires some Sunday work, and they naturally do not care to work overtime any longer than is necessary.

Assume you are to wash out a boiler tomorrow, which we will say is Sunday. First, prepare for the work today, as every tool and all supplies looked up today will shorten the time required tomorrow. Be sure you have manhole- and handhole-plate gaskets of the right size, and, if of rubber, see that they are not rotten. Have an extra handhole plate also a crab or yoke. See that the hose is in good condition and have a packing for it as it will take time to cut one tomorrow. Have a sharp cold chisel, a hammer and a 2-foot monkey wrench, also a piece of 2-inch shafting long enough to reach from the floor of the combustion chamber to the nut on the rear handhole-plate bolt. See that all scaling tools are in good condition. Lay out the work as far as possible. If the check valve or globe valve needs repairs make a mental note of it. Burn the fire low and have the ashes off the grate soon after closing down. Leave the damper and ashpit doors open, which will allow air to be drawn in and evenly cool the grates, setting and boiler. Do not make the mistake of opening the smoke-box doors or the door in the rear of the setting or you will have a hot boiler to enter in the morning.

If a watchman is employed, have him open the blowoff valves about 6 a.m. Be on the job soon after the water is out to wash out mud before it is baked on the tubes and shell. Do not knock in the manhole plate till you are sure no steam is in the boiler, it takes but very little to burn you. Having done this, remove the front handhole plate, first being sure the water is all out of the boiler, for although the blowoff valve may be open the pipe may be stopped with scale.

In removing the rear handhole plate the nut can sometimes be turned off with a 2-foot wrench, but if it does not start easily, split it off with a chisel, first placing the above mentioned piece of shafting under it so as to have something solid to pound on. Now take out any loose pieces of scale that might be washed into the blowoff valve. Never carry an exposed light into a boiler until it has had a chance to air out, especially if there is any possibility of sewer gas having collected in it. After taking out the manhole and handhole plates close the smoke-box doors and with the damper open, a circulation will be started down the manhole and out the handhole which will clear the boiler of foul air. Wash out the boiler with water under a good pressure before entering.

Carry a light hammer and something to scrape with when entering the boiler and look along the seams, get up to the front head and sound the braces; if one is loose it will rattle when hit. Inspect the rivets and look down between the tubes for scale. Take a look at the feed pipe where it comes through the head; it may be nearly broken off. Assuming that this is a top feed entering the front head, see that it is securely fastened; if it can be wriggled around, it will be time break off at the threads where it enters the bushing in the head. Examine the rear head, tubes, braces and safety plug; scrape this off so that water can come in contact with the soft metal. If you see anything suspicious looking hit it, do not be afraid of breaking the boiler, if you can break it with a hammer it is time it went to the scrap pile.

After getting out of the boiler, take a look at the front and rear ends, the tubes and especially the blowoff pipe. Next, get into the furnace and note the condition of the walls and arch, look for fire cracks between the rivets and the edge of the plate on the circular seam; if you have a water arch over the fire door look particularly at the bottom castings. Note the surface of the grate and examine the connecting bars, cotter pins, etc., proper inspection of the grate will frequently save a shutdown.

You are now ready to close the boiler. Scrape all the old packing from the handhole plates and inside the boiler around the handhole; replace the plates and draw them up tight; turn on the water and in about five minutes look for leaks around the gaskets. If one leaks, draw off the water and remove the plate; you will usually find that some of the old packing had not been scraped off.

You can now feel reasonably sure that your job is well done; many troubles may arise that I have not mentioned, but when you meet one, sit down for a few minutes and plan how to overcome it.

C. C. HARRIS.

Springfield, Mass.

The following figures relating to the relative cost and efficiency of coal and of oil are current in California: Two and one-half barrels of oil are the equal of one ton of coal in thermal units. In other words, the same amount of heat can be obtained from 2½ barrels of oil as can be obtained from one ton of coal. But the difference in price is very great. Coal, producing the same amount of heat per ton as 2½ barrels of oil, costs in California anywhere from $6 to $8 per ton, wholesale. Two and one-half barrels of oil, figured at the market-delivery price of $1 per barrel, costs $2.50—a saving of from $3.50 to $5.50 on every ton of coal displaced by oil.

Questions Before the House

Comment, criticism, suggestions and debate upon various articles, letters and editorials which have appeared in previous issues.

Fan Formulas

In the remote issue of July 27, 1909, on page 154, appears an article entitled "Power Required by Fans," in which are given by William Sangster two formulas to calculate approximately the horsepower required by a fan used to exhaust hot air from brick kilns. The formulas are as follows:

(1) *Multiply the diameter of the wheel in feet by itself five times and by the number of revolutions per minute three times. Divide this result by* 10,000,000,000 *and the answer will give the horsepower required to drive a fan handling air at* 50 *degrees Fahrenheit.*

(2) *Divide* 511 *by the sum of* 460 *added to the temperature of the air in degrees Fahrenheit and multiply the horsepower found by rule* 1 *by this quotient. The result will give the horsepower required by a fan handling hot air.*

This last formula clearly shows that the horsepower required to drive the fan varies *inversely* as the absolute temperature of the air.

There is another formula given in "Steam Boiler Construction," by W. S. Hutton, on page 84. It is as follows:

Let

P = Pressure of air delivered by fan in pounds per square foot,

V = Volume of air at 32 degrees Fahrenheit, in cubic feet, used per pound of coal,

W = Weight of fuel in pounds burned per square foot of grate per minute,

A = Area of the grate in square feet,

T = Absolute temperature of air entering fan in degrees Fahrenheit,

C = Coefficient of the efficiency of the fan, which varies in practice from 0.2 to 0.5.

Then, the indicated horsepower required to drive a fan equals,

$$\frac{P \times V \times W \times A \times T}{33{,}000 \times (461^\circ + 32^\circ) \times C}$$

It is true that this latter formula assumes data quite different from those which the former does. But into both the item of absolute temperature enters and has been taken as a determining factor.

It should be noted, however, that the formula given by Hutton makes it quite clear that the horsepower required to drive a fan varies *directly* as the absolute temperature of the air.

Thus it will be seen that the formulas are contradictory one to the other, or, at least, they seem so to be.

As air or gas is heated it becomes lighter in weight and larger in volume. It might be reasoned, therefore, that to handle a comparatively light gas at a higher velocity, a smaller amount of power would be required. But, on the other hand, it is to be observed that as the air is hotter it is greater in volume, and as the sectional area of the air passages remains the same, the column of air becomes longer and, thus, the space through which work is done increases.

MANILAL K. DESAI.

Ahmedabad, India.

Heat Value of Coal

In the very remote issue of POWER of July 14, 1908, on page 50, appears a contribution on the "Heat of Fuels, Etc.," by Prof. William D. Ennis. After elaborately discussing the process of combustion and the losses incurred in heating and evaporating the elements in the fuel and air, he comes on to the "Chemical Composition Determining its Heat Value." Here he says that the one pound of fuel contains 4 per cent. of hydrogen and 3 per cent. of oxygen, the rest, 93 per cent., being carbon. Of the 0.04 pound of hydrogen,

$$\frac{0.03}{8} = 0.00375$$

pound (one-eighth part of the oxygen in the fuel) is combined with oxygen and is driven off as water at moderate temperatures, and is, therefore, unavailable for combustion. The remaining

$$0.04 - 0.00375 = 0.03625$$

pound of hydrogen produces

$$61{,}800 \times 0.03625 = 2230 \text{ } B.t.u.$$

These heat units produced by the hydrogen uncombined with oxygen, added to the heat units produced by carbon, viz.,

$$0.93 \times 14{,}500 = 13{,}500,$$

amount to 15,730. Here, the forty-fourth and forty-fifth lines of the last column on page 51 are susceptible of correction. They read thus, "B.t.u., leaving 15,357 B.t.u. as the net heat of the coal 15,730 B.t.u. from which should." With the correction they should read thus, "B.t.u., leaving as the net heat of the coal 15,730 B.t.u., from which should." What I mean to say is that by taking only the uncombined hydrogen and carbon as the fuel, we have to deduct a quantity of heat which is equal to the difference between the heat produced by the whole hydrogen,

$$0.04 \times 61{,}800 = 2472$$

and the heat produced by the uncombined hydrogen

$$0.03625 \times 61{,}800 = 2230,$$

that is,

$$2472 - 2230 = 242$$

B.t.u. Deducting this from the total heat

$$13{,}500 + 2472 = 15{,}972$$

B.t.u., we get as the net heat of the fuel

$$15{,}972 - 242 = 15{,}730$$

B.t.u., and not 15,357 B.t.u. Of course, this may be a misprint or perhaps a misunderstanding and it is not very important.

Going down further, the author deducts the heat units which are necessary to heat and evaporate this uncombined free hydrogen, thus,

$$9\,(180 + 966) \times 0.03625 = 1146 \times 9 \times \left(H - \frac{O}{8}\right) = 373$$

B.t.u. Thus, the net heat value is,

$$15{,}730 - 373 = 15{,}357$$

B.t.u. So far, all is right. But in the formula, this last item, 373 B.t.u., is not deducted, as it should have been. The formula, as given, stands thus:

$$14{,}500\,C + 61{,}800\left(H - \frac{O}{8}\right)$$

According to this, the B.t.u. in the one pound of fuel are

$$14{,}500 \times 0.93 + 61{,}800\left(0.04 - \frac{0.03}{8}\right) = 13{,}500 + 61{,}800 \times 0.03625 = 13{,}500 + 2{,}230 = 15{,}730$$

while the heat units in the one pound of fuel, as calculated above, are 15,357. I think, therefore, that the formula needs correction, thus:

$$14{,}500\,C + 61{,}800\left(H - \frac{O}{8}\right) - 10{,}314\left(H - \frac{O}{8}\right)$$

According to this, the one pound of fuel has

$$14{,}500 \times 0.93 + (61{,}800 \times 0.03625) - (10{,}314 \times 0.03625) = 13{,}500 + 2230 - 373 = 15{,}357$$

B.t.u., which is correct.

The above formula, as corrected, can be expressed thus:

$$14{,}500\,C + 61{,}800\left(H - \frac{O}{8}\right) - 10{,}314\left(H - \frac{O}{8}\right) = 14{,}500\,C +$$

$$\left\{(61{,}800 - 10{,}314)\left(H - \frac{O}{8}\right)\right\} =$$

$$14{,}500\,C + 51{,}486\left(H - \frac{O}{8}\right)$$

With all due respect for the learned professor and others concerned, I draw their attention to this, and if I am not wrong, I ask for the adoption of the formula, as corrected above. If I err, will someone kindly explain where and how?

MANILAL K. DESAI.

Ahmedabad, India.

Lead Gaskets

Mr. Binn's article on manhead gaskets in the May 24 issue recalls my experience with the manheads as sent out with the Atlas boilers. I did the same as he but instead of using the lead alone I found, after filling and using it once or twice, thereby making a groove or channel, the exact thickness of the metal around the manhole and by using a layer or strand of asbestos wicking properly graphited and placed in the groove, made an excellent job. The wicking can be quickly and cheaply renewed and preserves the lead, its purpose being to prevent the metal from cutting the channel any deeper. When cleaning the boilers every week the lead would last from 8 to 12 months while carrying 120 pounds pressure and give entire satisfaction.

JOSEPH STEWART.

Hamilton, O.

Installing Globe Valves

This question is deserving of a large amount of consideration because dependent upon it are the lives of engineers, boiler attendants and other persons. The fallacy of connecting valves to a boiler with the pressure beneath the disk is frequently proved. The threads upon the valve stem are the only resistance against the load, which is obviously equal to the area of the valve multiplied by the pressure per square inch; consequently the threads on a 6-inch valve, where one hundred pounds pressure is carried, must withstand a load of about 2800 pounds. The threads soon become worn out from constant use and leave insufficient thread contact.

The principal argument against connecting valves with the pressure above the disk is that in this way it is difficult to pack them. That is very true, but if valves are packed regularly when the boiler is shut down and not let go until they begin to leak, this difficulty would not take place.

Another very important feature which should not be overlooked is that of placing intermediate valves in the lines. This affords an easy access for repairs which otherwise would be neglected. The question is of vital importance, especially where changes are to be made and the steamfitter takes the job on contract. Unless there are specifications for him to follow in regard to proper piping, it is probable that he will make it as profitable as possible regardless of safety. If the supervision of this class of work were left to a competent engineer, he would undoubtedly see that the job was done properly, for his own safety as well as that of others; instead the responsibility is often left to those who introduce such unreliable methods.

The writer recalls an instance in which there were no intermediate valves in the steam lines, and one morning just before starting time, the main stop valves were being opened on the boilers when one of the engines unexpectedly started up cold and came to a sudden stop on the center. This was due to the pressure being beneath the disk of the throttle valve and a water hammer had driven the disk upon the valve stem. However, after the fireman had closed the main stop valve which had just been opened, the engine was moved off center, and the main stop valve was opened gradually until the engine was up to speed. After the day's run the stop valves were closed and a new disk put in place. There was no drip pipe at this engine to relieve the steam pipe of condensation above the throttle, consequently the only means of doing so was by way of the lubricator.

The whistle was an old-time affair and was used very frequently during the day. In this case a globe valve was used with the pressure acting below the disk and from constant use it gave way early one afternoon and the whistle continued to blow the remaining part of the day. There was no other valve in the line and steam could not be shut off until night when the pressure was dropped on the boiler.

The writer could enumerate many more inconveniences of this kind but it appears that people will not be brought to their proper senses until the penalty is paid.

JAMES G. SHERIDAN.

New York City.

Loose Crank Pin

Referring to P. C. Forgard's contribution in the June 7 issue under the above heading, I suggest the following as the cause of the trouble, the pin is out of line.

As a remedy, I suggest a new pin.

H. B. BRAND.

Brooklyn, N. Y.

Brains vs. Temper

In the May 3 number of POWER there appeared an article entitled "Brains vs. Temper." I have looked each week for some comment on this article, but thus far have seen nothing. It seems to me that in the Commonwealth of Massachusetts it is remarkable that an engineer (presumedly holding a first-class license) should be found who would connect up the drips of a pump as stated, and still more remarkable that an expert (?) from the manufacturers of the pump should work all day without discovering what was amiss. Really, I think the first part of the title is superfluous, there being nothing in evidence except "Temper."

X. Y. EGAN.

Bennington, N. H.

Boring a Pump by Hand

While looking over the practical letters in POWER for June 14, I became very much interested in the article by F. C. Holly regarding the method of boring a pump cylinder by hand power. While I do not want to detract from Brother Holly's credit, owing to a similar experience of my own, I think I can add a few suggestions in the way of improvement. In the first place, in order to have the cylinder bored true, it would be better to have the guide *A* bolted to the face of the end of the cylinder, using two of the cylinder bolts for the purpose. The guide or strap *A* having two oblong holes to faciliate centering the shaft. After centering, these two bolts or nuts should be screwed up as tightly as possible. By so doing all possibility of springing the shaft while turning is eliminated. Regarding the feed, I don't quite understand the diagram as the feed screw is on the steam end. This being the case, and as the cut was started from the outer end of the cylinder, the feed screw would have to pull the cutter along thus creating quite a strain on the angle iron *B*, a tendency to pull or spring it out of position and a tendency to bind the thread.

Another little suggestion is that two men will be required to do the job, one to turn the shaft and another to attend to the feed screw. Anyone who has had lathe experience probably is aware that when turning up a piece of work where there is the least possible tendency to spring if the feed is not continuous and the tool turns around twice in the same place there will surely be a groove dug and as no two men can work absolutely together we adopted another and I think a better way. In place of the angle iron *B*, shown in Brother Holly's sketch, we put another strap across the face of the end of the steam cylinder and centered the rod or shaft at that end. A thread 24 to the inch was tapped in the center of the strap on the water end and a thread cut correspondingly on the shaft, back of the cutter, long enough to take the whole length of the cylinder. By this method the feed was made automatic, as when the shaft was turned around the feed worked correspondingly. An old throttle wheel was used in place of the handle shown in Brother Holly's diagram thus giving a better grip with both hands and a more steady pull and cleaner cut. Two cutters were used, one back of the other,

the last one being a broad-nosed tool. The cylinder in question was 8x12 inches in size and brass lined. The job was done by one man without removing the pump from its original position.

CHARLES H. TAYLOR.

Bridgeport, Conn.

Clutch Pulley Trouble

In the June 7 issue of POWER, F. E. Haught asks for information about a clutch pulley.

If his line shaft is not too small, a quill could be installed with a saving in the matter of belting, pulleys, etc., and space taken up by a countershaft.

In the power house in which I am employed, we have a quill running on a 6-inch shaft and driving a compressor that was installed last August. We have had no trouble whatever with the installation.

WILLIAM BEATON.

Gold Roads, Ariz.

Shrinkage Fits

In the issue of June 14 appeared an article on putting in new crank disks or pins. It has always been a question in my mind whether it is safe practice to apply heat. Considering the entirely unknown shrinkage effects, which no one can figure as there is so much to consider and know, great caution should be exercised when subjecting the disk to the strain of cooling off. It is the usual practice of some engineering firms to allow 0.0001 inch per each inch of pin or shaft diameter. But usually the pins are pushed in cold except in the case of a built-up marine crank which is always made of steel. In such a case heating can hardly do any damage. But with the usual cast-iron disk, I think that every time shrinkage is resorted to a chance is taken of splitting the disk.

In making repairs it takes but little to cause an accident that would disable an engine until another disk could be cast or secured from the engine builders. In either event the delay would probably be long and might prove costly. I had occasion once to put an 8-inch crank pin into the low-pressure disk of a cross-compound engine which drove a 1010-kilowatt generator and, although not believing in shrinkage jobs, to save time it was suggested that the disk be slightly heated. But the builders would not allow any heat whatever although they were ready and willing to assume responsibility for any damage resultant from pressing in a pin which was 0.0001 inch to the inch large.

J. W. HAMILTON.

Redondo Beach, Cal.

Drop in Steam Pressure

In the June 21 issue, Mr. Satterfield asks for enlightenment as to what a reasonable drop from boiler pressure to the maximum pressure in a Corliss-engine installation should be. While 16 pounds is too much for good practice it is by no means uncommon. The engine in his case may have insufficient area in the steam ports or an excessive steam lap.

A number of diagrams in the writer's possession taken from 40 Corliss engines and six automatic four-valve engines show an average of 10.6 pounds drop in pressure in the cylinder. These engines were running under all sorts of conditions as to load, etc. With few exceptions the diagrams were not taken under test conditions, the steam-pressure readings being taken from the boiler gages in the various plants in which the engines were located.

The drop in pressure ranges from 0 to 30 pounds, the diagrams showing a 30-pound drop having been taken from an engine located over 100 feet from boilers.

Out of the 46 engines only one, a slow-speed Corliss pumping engine with 125 pounds steam pressure, showed no drop in pressure; one engine showed a drop of one pound. Three of the engines have a drop of 21, 24 and 30 pounds respectively. As this must be due to unusual and abnormal conditions a fairer average of 9.37 pounds drop is obtained by eliminating them from the calculation.

F. C. HOLLY.

Yazoo City, Miss.

Concerning the Superintendent

I was much interested in Mr. Stewart's letter in the June 21 issue of POWER, for I have had the same experience myself.

It is very discouraging to an engineer to have a man by virtue of his authority completely overrule all sensible ideas.

What does an engineer think of his superior when the latter advances theories that are at once foolhardy and ridiculous? A man in such a position should compel the respect of those under him by his treatment of them and by making them think that he is in control by virtue of his knowledge. I do not mean that he must know everything, for that is impossible. But he can approach a subject in such a manner that the man in the engine room will feel that his advice is being followed and thus have more interest and confidence in his position.

I know of a plant where every little contemplated change is put up to a number of technical students and after more or less consideration some of them will saunter down to the engineer, find out his idea and then walk away. In a few days the change will be made and it is so much like the one proposed by the engineer that one would think that he should get credit for it. But more often one of the students is "patted on the back."

This also brings to our attention the editorial, in the same number, on consulting the engineer. Cases similar to the one mentioned are so common that we are getting used to seeing them. There is, for instance, a large power house being built for a manufacturing plant. All the machinery is being laid out by a man with a pull, who is just about as capable as a two-year-old child for the work.

The engines were first erected in the open and a temporary wooden structure put over them. The roof of this was made so flat that the first rain left a small pond on top which kept the generator well sprinkled for several days after the storm. Some temporary foundations were built in which some of the bolts were about 3 inches out of line with the holes in the machine and, of course, this was not noticed until the concrete had set. The offending bolts were cut off.

When cold weather came, regardless of the warning of the engineer, there were no precautions taken to prevent freezing. As a result the plant did not get started in time, for most of the piping was frozen. Then, there was a great hurry and steam was piped about a hundred yards from another plant; holes were stopped up and by using the greatest care the plant was kept in operation. These are only a few of the blunders that were made and there will be many more before the work is finished. Any of these could have been prevented if the engineer had been consulted and the money saved would have paid his salary for several years.

G. H. KIMBALL.

Southbridge, Mass.

Low Pressure Turbine

I read with interest the editorial in POWER for June 28 on the suggestion of using the low-pressure turbine as a second cylinder in connection with a single-cylinder reciprocating engine.

In 1906 a low-pressure turbine was installed as a third cylinder of a cross-compound engine in a large manufacturing plant. The original equipment consisted of two large cross-compound engines, located in two power houses. One engine furnished power through shafting to the various machines in one portion of the plant and also operated a small three-phase alternating-current generator. The other and larger engine operated a three-phase direct-connected generator. Improvements were to be made and the entire shops were to be equipped with induction motors. There was a shortage of power while the new power house was being built and while the old engine was being moved. The direct-connected unit being too small for the extra load, a low-pressure turbine was erected just outside the engine room and connected to a receiver, which was connected to the exhaust pipe of the engine.

This installation was made without any interruption of service, the exhaust pipe being connected at night.

When all was complete, the engine was started up. The average receiver pressure between the low-pressure cylinder and the turbine is 10 pounds. The turbine starts to move with from 3 to 6 pounds pressure in the receiver. When it is up to speed and voltage, the generator is connected in parallel with the one on the engine, and runs as long as the engine does with practically no attention. The turbine has no regulator, it simply takes the steam from the low-pressure cylinder. Tests and the general running of this installation proved so satisfactory that the company decided to use a second low-pressure turbine in connection with the other compound engine. This will greatly increase the capacity of the power plant without requiring much additional space for the turbine.

R. A. CULTRA.

Boston, Mass.

On Engineers and Wages

From time to time there appears in the columns of POWER discussions of the question of payment for services rendered by the steam engineer in charge of a plant, as compared with the payment for services rendered by other craftsmen, and I have thought a few remarks from one who has had an experience that seldom falls to the lot of man, might be acceptable even though they do not solve this very complex question.

A graduate from the machine shop and engine room rather than from the technical college, one who is both employer and employee, who at times scratches the bald spot on a very poor man's head, and at other times sails his own yacht "over the bounding billows," and who at all times is a believer in the square deal, I think I am without bias, and only regret that in discussing this question I may have to tell of my own experience more than I would wish to, but hope that the readers will excuse my seeming egotism if any appears.

After several years of experience in marine shops in New York, I obtained my first position of real responsibility, one as "chief engineer" (there was the fireman and myself) of a factory out in the country.

Now this factory had not been kept up in good shape. The fireman had been allowed to do as he pleased, and the proprietors thought that an engineer that would grab a squirt can and squirt oil all over the engine whenever the boss came round and sweat and stink while giving a nice song and dance about how difficult it was for him to keep up steam, etc., must of necessity be a first-class man.

I took charge; the first thing to be done was to reform the method of firing. I had to "lick" the fireman before he could be made to understand. There were four small boilers in use, and it required the power of two of them to run the engine while the steam from the others was used in the dye house and for heating, etc. Everything was driven to the limit.

Knowing something of the "science of steam," I concluded that the boilers were strong enough to carry a ten pound higher pressure which would enable a back pressure of five pounds to be carried on the engine without reducing the transmitted power, and with this five pounds back pressure the exhaust could be made to run the dye house, serve for heating, etc.

After much pleading the change was made with very gratifying results, to the engineer at least. During the following December, about a year after I had taken charge, and at the time of annual stock taking, one of the proprietors came into the engine room and said that they were all at sea regarding the coal consumption during the last year. As I remember it, he said:

"William, at the time you came here we were about to buy another 50-horsepower boiler in order to keep up steam. We did not buy the boiler, have never had to shut down for want of steam, have during the past year turned out our usual complement of finished product, but it seems as if we had burned 600 tons less of coal. Now, how is that? Could it be possible that a mistake was made in the inventory last year, or have the coal merchants neglected to charge for some cargo?"

Then it was William's time to grin, as he explained how it had all come about, and he took the hot air he was deluged with in the expectation that his Christmas turkey would be a fat one. But as Christmas came and went without his seeing the bird, the hope was that it would come as a New Year's present and as the coal delivered in the bunkers cost over $4.50 per ton the disappointment was great when nothing was offered except the hot air referred to above. However, when later on I asked for a raise of $1 a day, I got it, P. D. Q.

Now I know that others have done for their employers as well as in the above case, and have never secured any reward. This brings up the question, why?

Is it not because the engineer was too modest to assert himself and ask for it? Or, is it because having brought a run-down plant up to a high state of efficiency where the engineer can take his comfort, he knows that his employers can, for a time at least, get along with a cheaper man and he is afraid to ask better compensation for fear that he will lose the job. If not this, then what is it that compels him to submit to inadequate compensation for the service rendered? Who can answer?

As an employer, I find that the most skilful men are the cheapest to hire. By paying above the "prevailing rate" I win out, as the class of men employed are intelligent enough to know that my success in business means the continuation of the easy boss. I admit, however, that this scheme could not be successfully carried out where large numbers of men are employed.

But this is a digression. What we want to determine is why are there so many poorly paid and hard-worked stationary engineers.

This class of men cannot well avail themselves of a trade union, for obvious reasons. Take the way in which many of them are made. A good lusty greenhorn is put to work firing, and right here the writer admits that it is his preference to take the greenhorn in preference to the seasoned fireman, as he can generally teach the greenhorn to do the work the way he wants it done, while the seasoned man has his way which he cannot, or will not change.

Soon the fireman is allowed to stop and start the engine, help the engineer take up lost motion and make repairs, and soon the "boss" concludes that by raising the fireman's wages a trifle he can dispense with the services of his higher-priced man.

Now, whose fault is this? The average mill or factory owner is busy with the office end of the business, must look out for the purchase of raw material, the sale of the finished product, etc., and can scarcely be expected to distinguish between the really first-class man who generally is modest and retiring, waiting in the hope that by some miracle the boss will learn of his merits, and the loud-mouthed faker who by his cheek manages to get the center of the stage.

Is it not rather up to the really good engineer when he is about to make a change to first look over the plant, determine what improvements he can surely make, and then make his bargain *before* he takes employment?

It is the writer's practice when he is about to take employment to state his price for services, and he is terribly disgusted when he is about to employ help and asks what wages he is expected to pay to be answered by, "Whatever you say is right, goes." If the man who has the service for sale does not know its value, how can the proposed employer be expected to know?

In an experience of over forty years in office and engine room, I have never heard of an employer going to his engineer with a threat to discharge him unless he took more pay, and I believe that the horrible conditions under which many engineers work is their own fault because of their failure to insist on better sanitary conditions.

An article in POWER of recent date intimated that there is a project on foot to improve the condition and standing of the stationary engineer and while wishing it God speed I cannot see how it can

be done unless we can get rid of the beer-guzzling bums and grafters that hold down real engineers' jobs, for while the writer is not by any means a blue-ribbon man he believes it is this class of man that conveys the impression to the public that the engineers of small plants at least, are low-lived fellows whose chief end in life is to draw a theoretical diagram with the end of a dirty finger in a pool of beer on a bar-room table. All of which means that before we can greatly improve the condition of the engineer we must improve the character of the men. Then we can show the employer that it is good business to pay higher wages to a clean-cut man who knows the meaning of good treatment.

This rather rambling harangue has been written at intervals and amid much confusion. It is not as explicit as I would have it, but I trust that, such as it is, it will set some members of a very worthy class of men to *thinking*.

W. H. ODELL.

Yonkers, N. Y.

Questions for Hoisting Engineers

I was much interested in the questions for hoisting engineers which appeared in the July 5 issue and would like to offer a few criticisms.

The majority of the questions are perfectly fair and of such nature that anyone who was fit to serve in the position for which they were given should have been able to answer. But there are two or three questions such as No. 4 and No. 11 which are rather too much on the theoretical side and would be more in place for an examination for a designing engineer than for a practical operating engineer. While it is undoubtedly a good thing for engineers to be acquainted with methods of design, it is hardly an essential requisite for a practical operating engineer.

As regards questions No. 5 and No. 6 the data given are insufficient to allow of any answer at all. In question No. 5 the bursting pressure of a 72-inch by 18-foot return-tubular boiler is asked. As the bursting pressure of any boiler depends mainly on the thickness of the plate used, it would be impossible to state the bursting pressure unless the thickness were given. In question No. 6 the revolutions per minute of an engine are asked, given the diameter, stroke, steam pressure and horsepower. As the mean effective pressure depends upon the cutoff, no satisfactory answer can be given to this question unless the cutoff is given.

W. L. DURAND.

Washington, D. C.

I have read carefully the questions used at the examination of hoisting engineers at Terre Haute, Ind., May 10 and 11, and printed in POWER for July 5.

Those questions which, in my estimation, are unfit for such an examination I will discuss in their order and in each case give the reason why I take exception to them.

5. (a) It is impossible to answer this question without knowledge as to the thickness of the metal, kind of joints, size of rivets, etc. (b) Impossible to answer due to the insufficient data given in 5 (a). (c) Assuming that this refers to 5 (a), an answer is impossible for the same reason as in the case of 5 (b).

6. (a and b) As the mean effective pressure is not given it is impossible to determine the necessary speed.

11. This question would hardly concern an operating engineer. Decisions on such questions are made by the designing engineers.

12. This question is an impractical, theoretical one and one which, in practice, I am convinced, would never confront an operating engineer.

16. (a) Is it theoretically possible to draw water vertically more than 30 feet?

22. (b) This question is ambiguous. The question should read, "When the pitch diameter," etc., instead of "When the diameter," etc.

23. (a) This question also appears to be ambiguous.

ERNEST PROGST.

Rocky Ford, Colo.

Trouble with the Tension Carriage

With reference to Mr. Thompson's request, in the July 5 issue, for opinions on the arrangement of his tension carriage. I will venture the assertion that his idea about reversing the two idlers is a good one, although I fail to see any reason why they should not work either way. All that I ever had any experience with were located as he suggests.

With the carriage located as per the sketch in his article, the traveling idler is required to take up the slack of the rope, and also to overcome the friction of the rope in the sheave of the stationary idler as well as the friction in the bearings. But even at that it seems strange that it requires so large an amount of counterweight to move the carriage.

It sometimes happens that the track will settle out of alinement and cause the carriage wheels to bind on the rails, more especially if the rigging for the carriage track is made all of timbers.

As to taking up the slack without adding so much weight I always found an efficient remedy in moistening the rope with an ordinary sprinkling can enough to allow a small amount of slippage. Of course, there must be sufficient weight to hold the slack after taking it up. When a given weight is not sufficient to take up a small amount of slack, due to the friction of the carriage and the rope in the sheaves, a little moistening helps out wonderfully. The slack usually shows most on one side of the strands of rope and the rope after becoming damp will slip some in all of the grooves and finally equalize.

In my experience with this style of rope drive I have never found one but that was first class and I consider the type to be ideal for many locations.

JOSEPH STEWART.

Hamilton, O.

Use of Superheaters

In the July 5 issue Mr. Holley makes inquiry as to the advisability of installing steam superheaters in return-tubular boilers in order to obtain dry steam at the end of a line 900 to 1500 feet long. While it is quite true that by using superheated steam at the beginning of a long run the steam would still be dry at the receiving end, it is very doubtful whether there would be any actual saving in such a procedure. Superheaters cost money and are only justifiable where the use of superheated steam will result in an increase in overall efficiency. In the present case there would not only be the expense of the superheaters but a considerable extra expense due to having to install them in boilers already in operation, and this extra item of expense would not be offset by any gain in efficiency.

With a well insulated pipe the loss of pressure even in a run of 1500 feet should not be over 2 or 3 per cent.; and by using a separator at the receiving end and slightly raising the pressure at the generating end, the steam would be in practically the same condition as if superheaters were used and less precaution taken as to the insulation of the pipe. The majority of steam-supply companies, by taking extra precautions as to insulation, are able to transmit steam from one to two miles with a loss of pressure not exceeding 10 per cent., and by the use of separators to furnish steam which is in every way satisfactory for use.

W. L. DURAND.

Washington, D. C.

We are furnished city water which passes through a 2-inch meter, then to a triplex pump and thence through another meter to a service tank about 60 feet above the pump. The pump was installed because the city pressure was too low to supply this tank.

Can some of the readers of POWER tell me why the readings of the two meters vary from 30 to 60 per cent.?

H. BLUE.

Kirksville, Mo.

Notes on Barometric Condensers

By Warren H. Miller

When selecting condensing apparatus it is of great importance to keep the factor of simplicity in mind, avoiding such devices as will add to the cost of upkeep and necessitate constant supervision. The barometric condenser is simple as well as reliable, and is particularly suited for many classes of service.

The tendency in modern power-plant design is toward reducing the equipment to the simplest form possible. As one looks back over the day's work at the power house, or turns over the sheets of the log book, it is always the repairs to the small auxiliaries that outnumber the troubles with the main engines.

It is the writer's belief that the men best qualified to lay out power plants are not those with mere drafting-room experience, but rather the engineers who have *lived* with the machines themselves, and have run, not one, but many power plants. To such an engineer, a multiplicity of small complicated apparatus, all tending, no doubt, to increase the total theoretical economy, awakens no enthusiasm. He has had to repair hundreds of such devices, and has never yet seen one that did not represent a larger repair account than any economy it had effected.

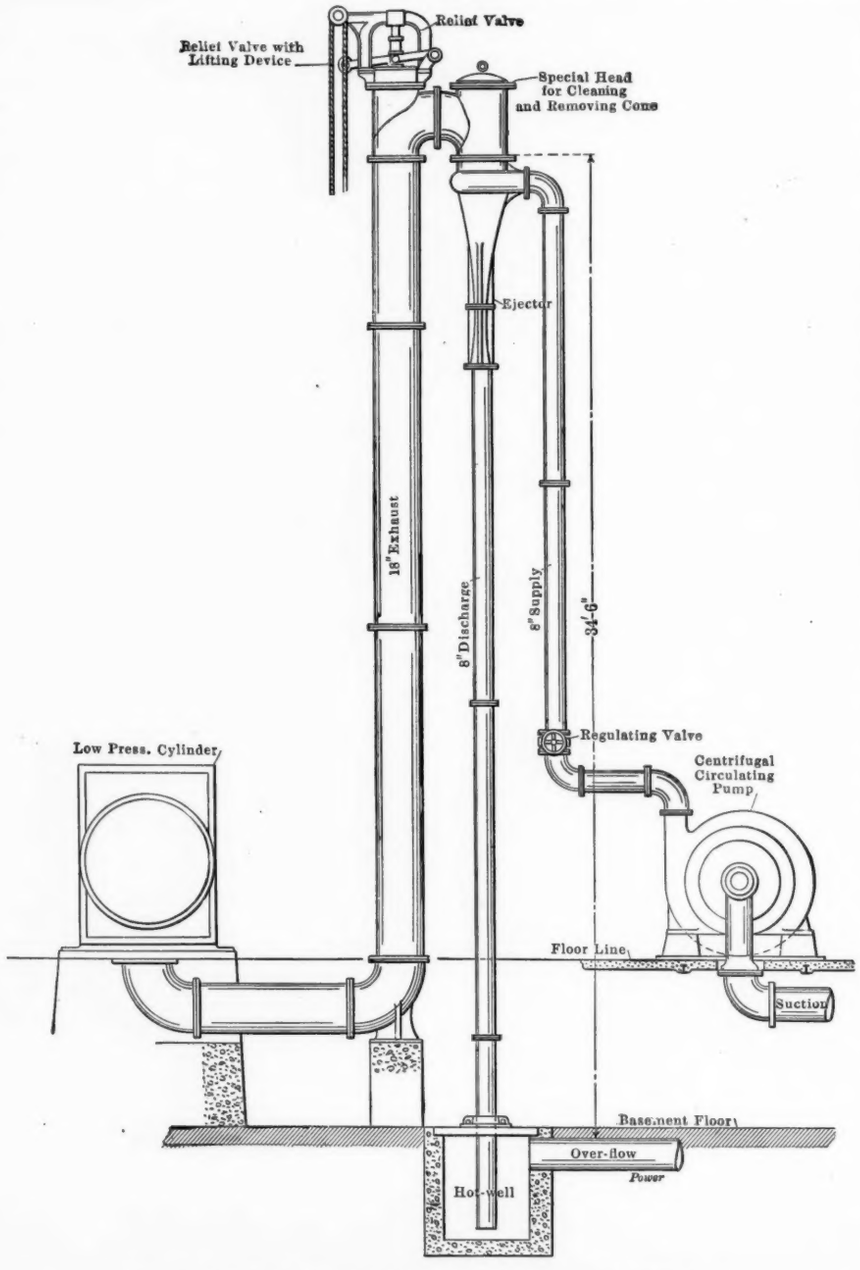


FIG. 1. GENERAL ARRANGEMENT OF BAROMETRIC CONDENSER

Particularly important in this respect is the condensing apparatus, which should be made as simple as possible to avoid the risk of shutdowns. For handling the circulating water, the substitution of an induction motor and centrifugal pump for a duplex or flywheel pump is one of the first improvements in the right direction. The combination of a small reciprocating engine or turbine with the centrifugal pump is sometimes used, but it is well to keep away, if possible, from both small engines and small turbines. As motive power for a centrifugal pump the induction motor is hard to equal, for simplicity, durability and general foolproof qualities. The pump itself will give little trouble if the suction is kept tight. A very little air, however, if entering the suction side, will soon stall the pump. Most of the air leaks in through the stuffing box, and the better makes have a double packing between which is a brass cage. This space is always full of discharge water, which, being of higher pressure than the suction, causes water to leak outward instead of air inward.

It is in the condenser itself that the greatest simplification can be obtained. The best economy of operation lies in the use of the surface condenser, as all the condensed water can be returned to the boilers as feed water, but, against this must be offset the fact that very little heat is returned with the condensed water. Practically all cylinder lubrication must be foregone unless one cares to risk the boilers with automatic devices for trapping the oil; and, if the water is salt or dirty, there is a possibility of further troubles with the boilers from salt and mud getting in through leaky condenser tubes. Finally there is the high first cost of the surface condenser—better spend the same money on better boilers and engines, or more of them. Unless one has to pay high prices for the boiler feed water itself, the surface condenser hardly shows enough superiority over the others to warrant its high cost.

If it is decided to waste the water and use jet condensers, the first simplification is to combine the circulating and air pumps into one, as is often done. Some form of flywheel pump is generally used for this purpose, but they often give trouble, because of having to handle such large volumes of water with so little clearance as is necessary in order not to destroy the vacuum through reëvaporation of the water vapor.

BAROMETRIC CONDENSERS

The simplest condensing device of them all is to eliminate the dry-vacuum pump entirely, use a centrifugal pump for circulating, and a barometric condenser to both condense the steam and remove the

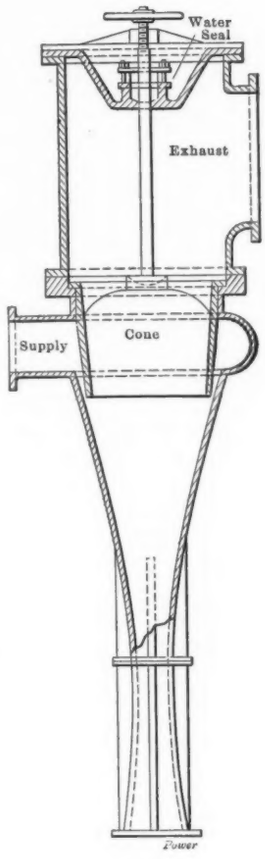


FIG. 2. SECTION THROUGH BULKLEY CONDENSER

air. Briefly stated, the barometric condenser is an ordinary jet condenser, discharging through an ejector into a vertical tail pipe 34 feet long. As is well known, a column of water 34 feet high will pull a vacuum by its own weight, and the ejector removes the air in much the same way that a steam siphon draws water. The water will never back up into the cylinders, as with a jet condenser, if the vacuum pump stops, for the column of water in the tail pipe is too heavy to be sucked back; if the circulating pump stops, the water simply runs out, the relief valve opens, and the engine runs noncondensing. When the water comes on again, the relief valve closes with a snap, and the engine runs condensing.

The argument usually raised against the barometric condenser is, that it cannot possibly take care of all the air without the help of a dry-vacuum pump, except with very short and direct exhaust connections. This argument is usually advanced by the dry-vacuum pump salesman, and he is very earnest and positive about it, so much so that the writer was once scared into having a boss cast on a new barometric condenser, and drilled and tapped for a 2-inch dry-vacuum connection, but it was never used. The last installation put in by the writer handled two 300-kilowatt cross-compound marine engines, a 100-kilowatt simple engine and a 70-horsepower duplex air compressor, all on a 14-inch exhaust pipe. There were 80 feet of 14-inch exhaust pipe and three 6-inch flanged tees on the line, besides a 14-inch base ell. With the two engines alone, 300 gallons of condensing water were required per minute at 70 degrees entrance and 118 degrees discharge temperature, the vacuum being 28½ inches. With the 100-kilowatt simple engine added, the vacuum fell to 25 inches; and with the air compressor further added, the vacuum dropped to 18 inches, while the discharge temperature rose to 135 degrees. This drop of vacuum was not because of air, but because the condenser was of only 1000 horsepower capacity on a 26-inch vacuum, and the exhaust

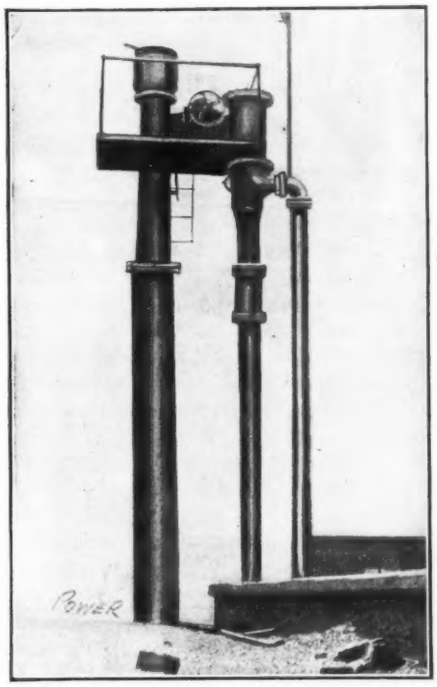


FIG. 3. BULKLEY CONDENSER IN SERVICE

of the two simple engines brought up the actual steam to be condensed far above this.

TYPES OF BAROMETRIC CONDENSER

Fig. 1 shows the general arrangement and Fig. 2 a sectional view of the Bulkley condenser. However, there is often a gate valve placed between the condenser and the exhaust main, not shown in the general-arrangement layout. The hight should not be less than 34 feet 6 inches from the joint in the condenser head above the water inlet to the level of the overflow water in the discharge sump. The distance from the center line of the riser to the center line of the tail pipe, with the valve inserted, is about 4 feet 2 inches; hence it is quite feasible to have the exhaust riser come up inside the power-house wall, and the tail pipe on the outside, spanning the wall, as shown in Fig. 3.

The interior of the condenser is simply a hollow, cast-iron, conical ring, with a spider and screw bolt for raising or lowering the cone. This is set at the factory, and should not be readjusted, except when absolutely necessary, as it gives just the right amount of water into the ejector. As will be noted from the illustration, the water is directed down the walls of the condenser, while the steam enters and is condensed inside the hollow cone. With it is the air, and the mixture of air, steam and condensing water shoots downward into the ejector where it acquires a high velocity, and, once the air is past the neck of the ejector, it must pass through the tail pipe. It is practically impossible to flood this condenser, as the cone moves in a tight fit, and the only conditions under which the water could reverse its direction would be if the cone were raised too high, admitting more water than the ejector will pass, and thus backing up into the exhaust pipe.

With jet condensers, where this is sure to happen if the air pump stops without the water being shut off, a good protection is to put a snifting valve on the low-pressure cylinder cover, with a spring to hold it open when once its seat is raised.

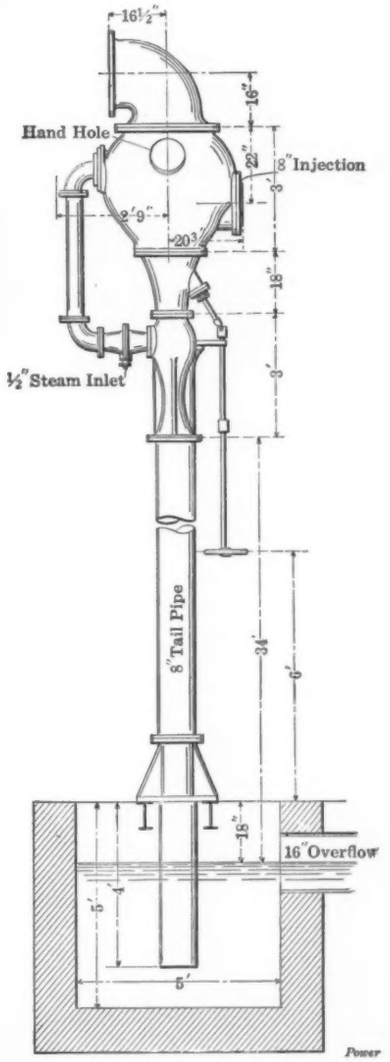


FIG. 4. WHEELER CONDENSER

The water always tends to go where the vacuum is best, so on flooding, a little of it immediately shoots back into the low-pressure cylinder. Here it is immediately driven out through the relief valve and the snifting valve, and the latter, remaining open, breaks the vacuum, and the exhaust pipe immediately fills with steam and drives the water out.

Fig. 4 shows the Wheeler barometric jet condenser. In this type the condenser and ejector are separate, and the latter has an air connection outside the condenser to suck the air out above the spray. A valve controls this spray, which spurts upward over a mushroom baffle plate. It must reverse before acquiring any downward velocity, and therefore has no means of catching the air above it, hence the outside pipe connection to the ejector. Both this condenser and the Bulkely can be connected to any vacuum pump, but it should never be necessary to use one.

Fig. 5 shows the Alberger barometric condenser with automatic spraying adjustment. In this condenser a small air pump is a necessity, as no ejector is combined with the condenser. All the water is carried off, however, by the tail pipe, and the hight of the column suffices to pull the vacuum; all the air pump has to do is to take away the air as fast as it accumulates.

Regarding the relative amounts of circulating water required by the surface condenser and the barometric condenser, it is more than likely that the actual

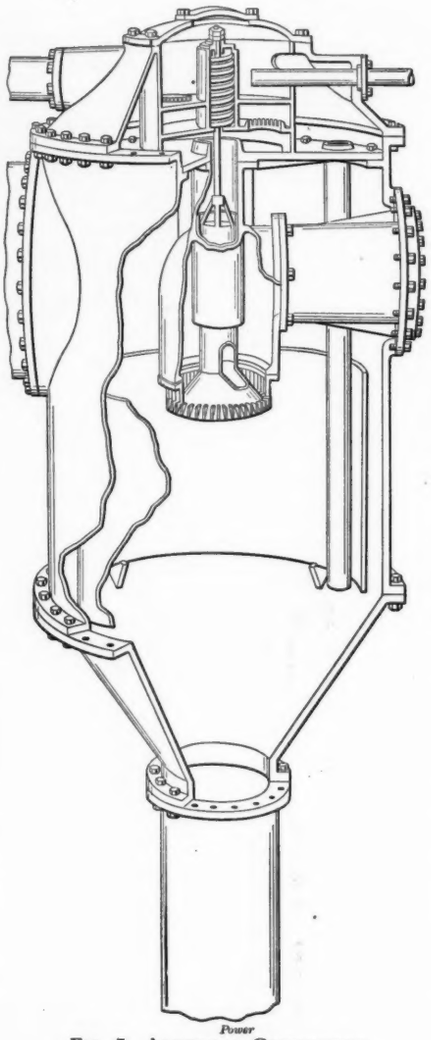


FIG. 5. ALBERGER CONDENSER

figures of the former equal, if not exceed, those of the latter.

A deciding factor in the selection of a condenser is the amount of vacuum that is actually needed. With the barometric type, without any dry-vacuum pump, 28 inches is easy to obtain and hold; even with leaky piston rings it will hold up to 26 inches. But, with a turbine, 29 or 29½ inches are well worth trying for, because the turbine can use these last inches to a great advantage. The ordinary compound, or the triple-expansion, or even the quadruple-expansion engine cannot utilize these last 2 inches, even if the condenser can produce them, because the volume of every pound of steam at 29½ inches vacuum is excessive, and no cylinder will take care of it. The best the ordinary compound engine can do is to exhaust into the condenser at about four pounds absolute, at which the steam occupies about 90 cubic feet per pound. This corresponds to a 22-inch vacuum, and, if one gets 28 inches, or even 26 inches, it helps principally by giving the exhaust a greater velocity into the condenser and cutting down the necessary area of the exhaust pipe. For turbines, however, very short and large exhaust mains should be used, and as a very little air will reduce the vacuum considerably, a dry-vacuum pump would more than compensate for the trouble and expense of keeping it in first-class condition.

[There are a number of types of barometric condenser on the market which are not mentioned by Mr. Miller. These include the Tomlinson, the Weiss, the Le Blanc and others.—EDITOR.]

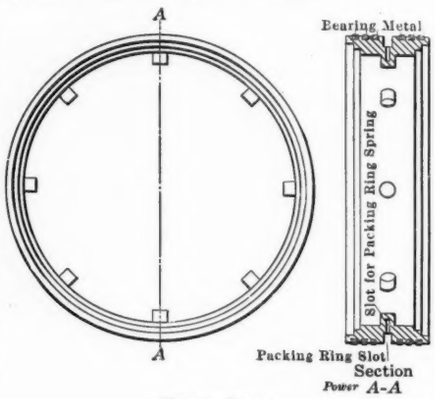
Frictionless Bull Ring

By C. L. Greer

To those who operate engines with large cylinders or have trouble from the wearing of bull rings, the following experience in the power station of the Northern Texas Traction Company may be of interest:

There was installed a 1500-horsepower cross-compound engine, the low-pressure cylinder of which was 52 inches in diameter. From the beginning much trouble was experienced from wear of the bull ring despite the fact that the ring was frequently shifted around to various positions. A liberal supply of cylinder oil and graphite failed to relieve the trouble and at the end of a year the ring was so nearly worn out that it would little more than hold the packing rings; these being in sections, it was feared that should water come over into the cylinder a section might be forced out of position and do damage.

The bull ring had two packing rings one near each side, while near the center were two strips of Allan metal which were embedded in slots around the ring. These strips of metal, about one inch wide, while helping some, did not furnish sufficient bearing surface to carry the heavy piston without excessive wear.



BULL RING

To overcome the difficulty a new ring was made as shown in the accompanying sketch. Only one packing ring was used. This was 1½ inches wide and placed in the center of the bull ring, while on each side were placed three rings of Allan metal, each ⅞ inch wide. This gave a total bearing surface of 5¼ inches.

The slots in which the Allan metal was placed were made about 1/16 inch wider at the bottom than at the top in order that the metal might be retained. The metal was tightly peened into the slots and finished about 1/32 inch larger than the bull ring.

After nearly a year's service the rings have shown very little wear, the cylinder has an excellent polish, and the bull ring has not been shifted from its original position. The bull rings of three other 900-horsepower engines in the plant have been similarly fitted and are giving excellent satisfaction.

Where trouble of the kind mentioned is experienced, it is economy to fit the pistons with some good frictionless bearing metal as it effects a saving in oil, power and wear on the cylinders and bull rings.

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Contents

PAGE

Economical Fire Room Methods..... 1370
Cleanliness in Power Plants..... 1375
Measurement of High Temperatures... 1376
Development of Chain Grate Stokers... 1379
Cold and Its Production..... 1381
Using a Sewer for Condensing..... 1384
Primer of Electricity..... 1385
Cheating the Electric Meter..... 1388
A Train Load of Gas Engine..... 1389
Surplus Power Available in Steel Works 1389
Keying a Creeping Flywheel..... 1390
Practical Letters:
Right Angled Drives....Repairing Ice Cans....Damper Regulators and Upright Water Tube Boilers....Piping Layout for Criticism....An Unique Application of Power....Some Properties of Saturated Steam....Spark Arrester....An Emergency Piston....Unusual Boiler Behavior....Oil Fuel in the British Navy....Hints to Beginners 1391-1394
Discussion Letters
Fan Formulas....Heat Value of Coal....Lead Gaskets....Installing Globe Valves....Loose Crank Pin....Brains vs. Temper....Boring a Pump by Hand....Clutch Pulley Trouble....Shrinkage Fits....Drop in Steam Pressure....Concerning the Superintendent....Low Pressure Turbine....On Engineers and Wages....Questions for Hoisting Engineers....Trouble with the Tension Carriage....Use of Superheaters 1395-1399
Notes on Barometric Condensers..... 1400
Frictionless Bull Ring..... 1402
Editorials 1403-1404

Power and The Engineer

Editorial

Engineers' Opportunities

How often are the educational opportunities afforded by meetings of engineers' associations taken advantage of and improved by those who attend such meetings? After the routine business is despatched and the question, "Has anyone anything to offer for the good of the order" is asked from the chair, what is the usual response? In most cases, it is safe to say, instead of an announcement from the educational committee that there has been provided a lecture or a discussion on some live topic, or the opening of the question box and the subsequent reading of the queries, the stereotyped "We will close in due form" follows.

Any one of the thousands of subjects upon which most engineers might easily be better informed would afford material for an evening's discussion, profitable to all present and especially to those who participate.

To the man who takes part in a discussion with a view to mastering a subject which to him has been a sealed book, there comes a new interest, and he is apt to seek other knowledge and become a more valuable member of the organization as well as a better informed engineer.

There are successful engineers by the hundred who owe their start in the proper direction to the fact that they have been compelled to grapple with special problems and struggle with these until all obscurities were mastered, the knowledge thus gained adding to their mental equipment.

Steam engineering is not an exact science, to be learned completely from textbooks, nor can its principles be absorbed by a desultory course of reading, in which the "knotty" subjects or statements are carefully skipped. Hours or days given to a problem will be time well spent if in the end the mastery is complete, and the value of such mastery is immeasurable. In other words, it is the study, not mere reading, that counts.

Through many channels the outsider is invading the field that is the engineer's own, and with a success depending upon the mental alertness of the engineer himself. It is obvious that the man in responsible charge of any power plant should know more about every detail of its operation than any outsider, however well trained. Special knowledge is the result of special training, and the engineer has better facilities for special training in his vocation than any other man in the world; he should follow up his advantage.

Economical Firing

If a man should give an agent a sum of money to invest in stocks he naturally would expect the agent to exercise sound judgment so as to insure the greatest possible return upon the investment. In a boiler plant, the coal pile represents a certain amount of the employer's capital entrusted to the fireman's judgment for economical expenditure. If a large percentage of the heat is allowed to escape up the stack it represents just that much money thrown away.

In many large hand-fired plants it is common practice to place one responsible man in charge of the boiler room and have the actual firing done by cheap foreign labor, the fitness of a man being judged not by what he knows about keeping a good fire, but by how much coal he can shovel. The advisability of such practice is open to question and it is doubtful if it tends toward ultimate economy. It seems that with the growing practice of forcing boilers it would be better policy to employ a more intelligent class of firemen who could be made to realize that more money can be wasted or saved in the boiler room than in any other part of the plant. Of course, to make this effective the fireman should be remunerated accordingly.

There are certain fundamental rules which must be observed in all boiler rooms in order to conform to good practice. These include maintaining clean, even fires, feeding moderate amounts of coal at regular intervals, delivering a uniform supply of feed water, blowing down and cleaning boilers at regular intervals (dirty heating surfaces mean more coal for the fireman to handle), regular times for cleaning the fires; if there be a battery of boilers the fires should be cleaned in regular order and the periods so arranged as not to affect the steam pressure on the line nor place undue load upon the other boilers.

Beyond these general rules the conditions at each individual plant will require special study and treatment accordingly. Different coals require different methods of firing and various conditions of load demand different rates of com-

bustion. It is very important that the proper amount of air be supplied for complete combustion; insufficient air supply will cause smoke, representing unburned particles of carbon wasted from the stack, while too much air means a loss in heat units which, instead of going to heat up the water, are utilized for raising the temperature of the excess air which passes up the stack. An experienced fireman can often tell by the appearance of the fire whether he is obtaining approximately perfect combustion.

One of the greatest aids to efficient boiler-room operation is the keeping of a complete log or record of the coal burned, feed water used, steam pressures, intervals of firing and cleaning, draft, etc. This not only permits the chief to keep a close supervision over the boiler room but also enables the fireman, by a comparison of results from day to day, to see where his methods can be improved. The fireman who takes the proper interest in his work will read up on combustion and will make a careful study of the conditions confronting him. The old saying that "the fire room is the place where brawn counts more than brains" can no longer be accepted.

Settings of Return Tubular Boilers

Although it is claimed by many, and with reason, that in the matter of progress the builders of boilers have been distanced by the builders of steam engines, there has been a marked improvement over the boilers that were in use twenty-five years ago. This applies particularly to the material put into them and the methods employed in their construction. A weak point in boiler practice, however, is found in the boiler setting, particularly in small plants where return-tubular boilers are largely used. When a manufacturer sells a return-tubular boiler, he loses all engineering interest in it as soon as it is loaded on the car, and forgets about it entirely as soon as a check balances the account. When the boiler reaches its destination, it is unloaded by most anybody and is probably set in position by some inexperienced person. Then the local brick mason is set at work, using either his own ideas or those of others connected with the plant as to the best manner of bricking in the boiler. The probabilities are that the engineer of the plant has never before had anything to do with setting a boiler, the superintendent knows less than the engineer about the work, while the mason's experience has been restricted to foundation piers and domestic chimneys.

A properly built boiler setting will not develop cracks in the side walls and rear connection within a few months after it is put into use, but if the expansion of the boiler is not provided for, the setting will be pushed out of place, no matter how well it may have been built; and if the workmen do not know how to set a boiler, proper provision for its expansion will not be made. It is highly probable that over fifty per cent. of return-tubular boilers are incorrectly set, not because of any lack of desire to do the work right, but because the workmen do not know how.

The makers of water-tube boilers do not sell them and allow the first mason found to do the brickwork. They know that it is absolutely necessary to have a boiler properly set if it is to come up to its rating when put to work, and for this reason the selling of a water-tube boiler means that the maker will also attend to the brickwork. The result is that the boiler is provided with a setting and furnace such as experience has shown to be best adapted to the type being set up.

If the builders of water-tube boilers find it of advantage to construct the settings and furnace of their boilers, it would seem that the makers of return-tubular types could learn a lesson from this practice that would be of advantage to them.

Perhaps building the furnace and setting of a return-tubular boiler would be a greater departure from the present general practice than is expedient or even necessary. However, if the builders of this type of boiler would determine by experiment just what type of setting is best suited for their particular product, with various makes of grates and grades of coal, and embody the results in specifications to be sent to each purchaser of their boilers, better results would be obtained from the boilers in regular work.

Coal Analysis

There are two methods of analyzing coals. The "proximate" analysis determines the proportions of moisture, volatile matter, fixed carbon, sulphur and ash in the coal; the "ultimate" analysis determines the proportions of carbon (total), hydrogen, nitrogen, sulphur and ash, and what is left is classed as oxygen. Just why oxygen should be saddled with all the mistakes and uncertainties of the analysis does not seem clear. The reason commonly offered is that there is no means of directly ascertaining the proportion of oxygen in coal; therefore, when everything determinable has been determined, what is left must be oxygen! This reasoning would be defective even if all the other constituents could be measured with absolute certainty, and when it is remembered that fixed carbon and ash are about the only constituents that can be measured with anything like accuracy, the defectiveness of reasoning degenerates into absurdity.

Aside from the scientific view of the matter, however, it is not only unwarrantable to charge all the uncertainties of analysis to oxygen but it gives a distorted character to the fuel. Free oxygen makes for free burning, and when an ultimate analysis shows ten per cent. of oxygen as compared with less than two per cent. of moisture in the proximate analysis, it looks to the uninitiated as though that coal were just reeking with free oxygen, waiting for a chance to grab some of the combustibles.

If there is any advantage or satisfaction in recognizing the oxygen which forms part of the moisture (which is of no importance whatever from the fuel standpoint), it can be assumed to be eight-ninths of the moisture content with less violation of scientific scruples than the present custom affords.

Why not be at least truthful and write the actually unknown difference as "undetermined?"

Man Is a Failure

When he has no confidence in himself nor his fellow men.

When he values success more than character and self-respect.

When he does not try to make his work a little better each day.

When he becomes so absorbed in his work that he cannot say that life is greater than work.

When he lets a day go by without making someone happier and more comfortable.

When he tries to rule others by bullying instead of by example.

When he values wealth above health, self-respect and the good opinion of others.

When he is so burdened by his business that he finds no time for rest recreation.

When he loves his own plans and interests more than humanity.

When his friends like him for what he has more than for what he is.

When he knows that he is in the wrong, but is afraid to admit it.

When he envies others because they have more ability, talent or wealth than he has.

When he does not care what happens to his neighbor or to his friend so long as he is prosperous.

When he is so busy doing that he has no time for smiles and cheering words. —*Louisville Times.*

The man who makes the same mistake a second time does not deserve to be excused.

To lend a hand is good policy; you never can tell when you will need a lift yourself.

On the average, a cent will purchase one hundred thousand heat units in the shape of coal; this is no excuse, however, for wasting any.

Inquiries of General Interest

Questions are not answered unless accompanied by the name and address of the inquirer. This page is for you when stuck—use it.

Condensing and Noncondensing

Should the valves of a Corliss engine be set differently when running condensing from what they would be for running noncondensing?

T. R. W.

No, the valve setting should be the same for both conditions.

Change of Cutoff

How can I change the point of cutoff on a Corliss engine?

D. R. J.

You cannot. That is the function of the governor which controls the speed by shifting the point of cutoff as the load and steam pressure vary.

British and United States Gallon

What is the difference between the British and the United States gallon?

C. F. P.

The British gallon contains 277.274 cubic inches and the United States gallon 231. A British gallon of water weighs 10 pounds and the other 8.34.

Diameter and Hight of Chimneys

Will you tell me what dimensions of chimney are necessary to properly take care of 66 square feet of grate surface? Our chimney is 30 inches in diameter and 70 feet high. Is that adequate? Also will you give me a rule for finding hight of a chimney without the use of a transit?

A handy rule for calculating the diameter and hight of a chimney for a given grate surface is: Make the area of the chimney one-seventh the area of the grate and make the hight of the chimney 25 times its diameter. This, in your case, would give a chimney 42 inches in diameter and about 90 feet in hight. Directions for finding the hight of a chimney without the use of surveyor's instruments were published in the issue of July 5.

Foaming and Priming

What is the difference between foaming and priming in boilers?

J. C. D.

Foaming is a violent frothy ebullition of the water in the boiler and is caused by an excess of impurities, while priming is the mingling of a fine spray with the steam and is usually caused by an insufficient steam-liberating surface.

Low Water

What should be done in case the water is out of the water column?

H. A. M.

The fire should be covered and the boiler allowed to cool until it can be entered and examined.

Boiler-feed Piping

How should water be fed to boilers?

S. B. R.

The feed pipe should enter the boiler through the front head near the shell just above the tubes, pass to the rear, cross to the opposite side, turn downward and discharge the water between the shell and the tubes.

Ratio of Expansion

The diameter of the high-pressure cylinder of a compound engine is 15 inches and that of the low-pressure cylinder 30 inches. If the cutoff takes place at one-third of the stroke in both cylinders, how many expansions are there?

H. A. S.

When steam is expanded in two cylinders the number of expansions is found by multiplying the number of expansions in the high pressure by the cylinder ratio. Neglecting clearance, condensation, etc., a cutoff at one-third of the stroke in the high-pressure cylinder would result in three expansions, which, multiplied by the cylinder ratio, which in this case is 4, would give 12 as the total number of expansions in both cylinders.

Strength of Boiler Plate and Pitch of Rivets

Will you please tell me why it is that boiler plate is not used that has a tensile strength of 100,000 pounds or as low as 30,000 pounds, but is always around 55,000 to 65,000 pounds?

How do you find the right pitch of rivets in a boiler joint with a single-riveted lap, a double-riveted lap, a double-riveted butt with two cover plates and a triple-riveted butt with two cover plates, when the thickness of plate and the diameter of rivets are known?

T. F. B.

One very good reason for not using steel of the tensile strength mentioned is because steel of such strength is not made for boiler plate. Steel of high tensile strength is deficient in ductility, and when of low tensile strength the elastic limit is low, both conditions being directly opposite to what is desirable for material for boiler construction.

When the shearing strength of the rivets is equal to the tensile strength of the plate, the maximum strength of a riveted joint, taking all the dimensions in inches, is expressed as follows:

$$\frac{\text{Pitch of rivets} - \text{(diameter of rivet hole)}}{\text{Pitch of rivets}} = \frac{\left(\frac{\text{Diameter of}}{\text{rivet hole}}\right)^2 \times 0.7854 \times \text{number of rows of rivets}}{\text{Pitch} \times \text{thickness of plate}}$$

$$\text{Pitch of rivets} - \text{(diameter of rivet hole)} = \text{(diameter of rivet hole)}^2 \times 0.7854 \times \frac{\text{number of rows of rivets}}{\text{thickness of plate}}$$

$$\text{Pitch of rivets} = \text{(diameter of rivet hole)}^2 \times 0.7854 \times \frac{\text{number of rows of rivets}}{\text{thickness of plate}} + \text{diameter of rivet hole}$$

Where there are two rows of rivets, then,

$$0.7854 \times 2 = 1.5708,$$

and for a double-riveted joint, measuring along one line of rivets.

$$\text{Pitch of rivets} = 1.57 \times \frac{\text{(diameter of rivet hole)}}{\text{thickness of plate}} + \text{diameter of rivet hole.}$$

Where there are three rows of rivets, then,

$$0.7854 \times 3 = 2.3562,$$

and for a treble-riveted joint, measuring along one line of rivets.

$$\text{Pitch of rivets} = 2.3562 \times \frac{\text{(diameter of rivet hole)}^2}{\text{thickness of plate}} + \text{diameter of rivet hole}$$

These rules apply to all thicknesses of plates and diameters of rivet holes.

Boiler Feeders and Repairs

What are used for boiler feeders? What should be done if they fail to work?

N. A. H.

Pumps, injectors and return traps. If for any cause the apparatus used fails, it should be immediately put in working order.

Safety Valves

What is the safety valve for, and how constructed, and where should it be placed?

F. E. D.

The safety valve is an appliance which prevents an excess of pressure by opening when any predetermined pressure is reached, allowing steam to escape. In a general way the safety valve is made like other valves of the angle type except that it is closed by a spring or lever instead of a screw. It should be attached to the steam space of the boiler independently of all other piping.

New Power House Equipment

What the inventor and the manufacturer are doing to save time and money in the engine room and power house. Engine room news.

Vacuum and Gravity Return Systems

An arrangement of the Stickle open feed-water heater and receiver with a vacuum pump discharging into the receiver, together with a boiler feed pump conected to the receiver and heater, and working in conjunction with them, is shown in Fig. 1. The idea is to prevent the waste water from the return drips, passing from the heater through the overflow pipe, in case an excessive amount of condensation should be returned.

Generally there is not enough space in the open heater, between the overflow line and the point where the automatic control admits water to the heater, to allow any considerable amount of condensation accumulating before some of it will escape through the overflow pipe.

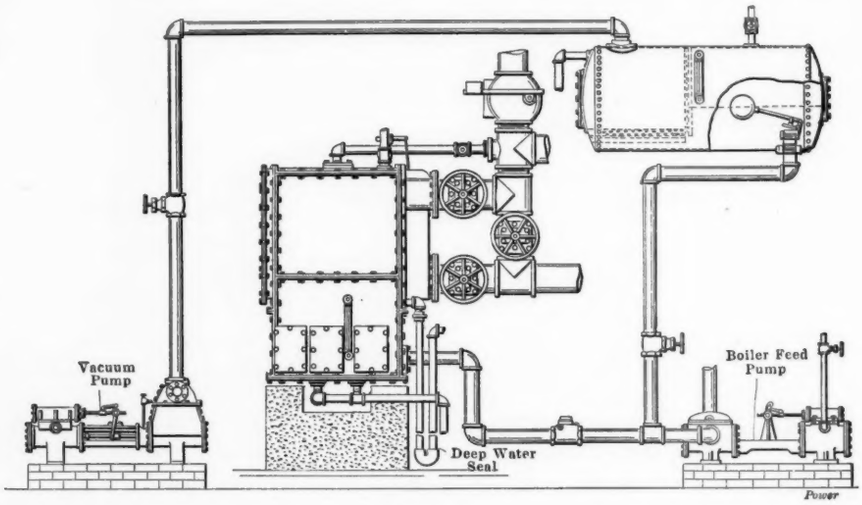


FIG. 1

The illustration shows the method of connecting up the heater with a vacuum heating system. With the receiver arranged as shown, the heater operates entirely by induction, no more steam entering the heater than is necessary to heat the water, consequently excellent results are obtained in oil separation, and this prevents the amount that is carried in the vapor from entering the heater; the balance of the steam going through the oil separator to the heating system.

The receiving tank, located above the heater, has a filter chamber packed with excelsior, with a downward filter that traps any oil that may get into the system. The float in the receiver drops when water is taken out by the boiler feed pump, which closes the valve. This allows the check valve in the section pipe between the heater and boiler feed pump to open, and allows water to come from the heater only when the supply in the receiver has been used, thus preventing any of the returned condensation to go to waste. When there is such a surplus of condensation returning that the feed pump will not handle it, the excess is stored in the receiver.

The heater can be cut out for cleaning without interfering with the heating system. In the summer time the receiver can be cut out, the exhaust steam passing through the heater to the atmosphere.

Fig. 2 shows a combination of feed-water heater, receiving tank and low-pressure traps. The boiler feed pump is connected to the receiver, which is piped to the atmosphere. The receiver works in conjunction with the heater automatically, and all returns come by gravity from the system to the receiving tank. The requirements are that the pump and receiver shall be located to conform to the gravity line of the returns.

By the arrangement shown, the open heater can be operated with a back pressure sufficient to deliver the exhaust steam to a point where it is used, free from oil, to the heating system, etc. The returns of condensation flow to the low-pressure steam traps, and thence to the receiver, which is open to the atmosphere and is connected to the suction pipe of the boiler feed pump, which operates automatically in conjunction with the open heater.

Each return is so installed that each coil will operate independent of one another discharging from pressure to atmosphere, which keeps the system clear and maintains a positive circulation.

By the method shown in Fig. 2, the receiving tank is sufficiently large to take care of the returns and will not allow any of the make-up water to come from the heater until the supply in the receiving tank has been used. Therefore, even though the amount of return may be excessive, the capacity of the receiver is such that none is permitted to escape through the overflow pipe.

The stickle open-coil heaters and traps are used with these systems, which are designed by the Open Coil Heater and Purifier Company, 502 S. Pennsylvania street, Indianapolis, Ind.

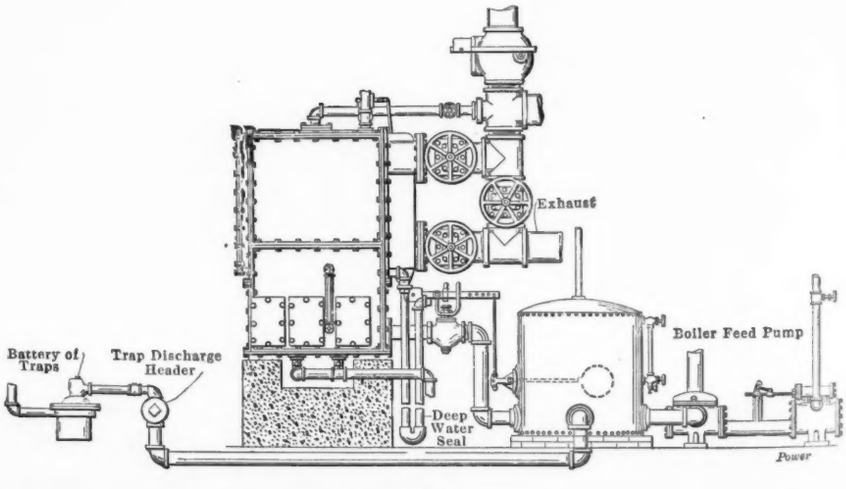


FIG. 2

Harrison Aertube Heater

The various savings that would be possible by the use of a direct fuel-to-air heater have led to the invention of several direct-heating systems, one of which is described herewith.

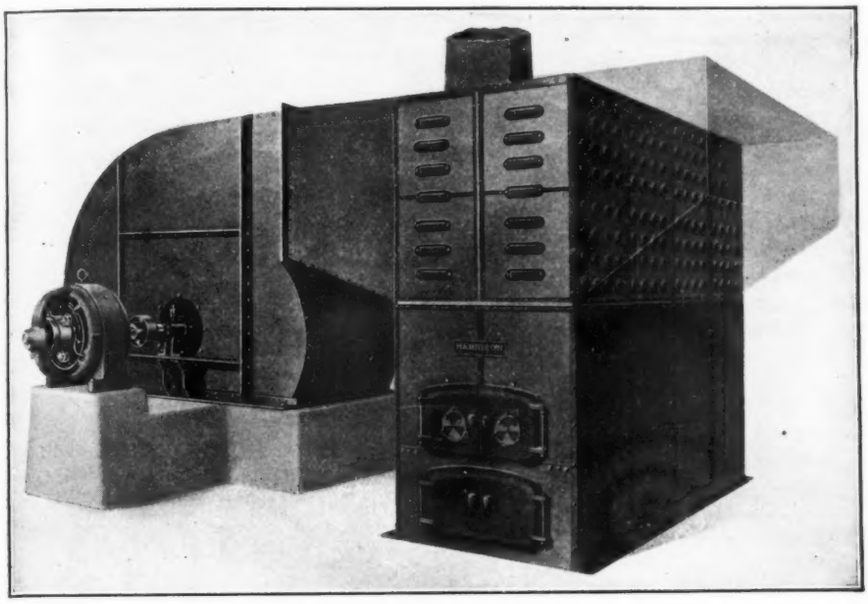


FIG. 1. HARRISON AERTUBE HEATER AND DIRECT CONNECTED ELECTRIC FAN

The Aërtube plant consists of a furnace under a bank of horizontal tubes, through which the air to be heated is driven by a fan to the distribution ducts connecting with the building to be heated. Fig. 1 illustrates a motor-driven fan and Aërtube heater. The heat from the fire strikes directly on the heating tubes and is distributed among them by baffle plates, as shown by Fig. 2. The transfer of the heat of the furnace to the air passing through the tubes is direct and immediate. An efficiency of 80 per cent. or more of the heating power of the fuel is guaranteed by the makers. In this type of heater the air passes through the tubes in a straight line from the fan to the distributing ducts, and parallel with the heating surfaces. The heater is made on the sectional plan, and so may be adjusted to the heating load in any special case.

While the Harrison system is applicable in any type of building, it is especially satisfactory where the heating system must also provide mechanical ventilation, and is particularly adapted to buildings which do not require steam for power purposes, but which have electric power.

The heater is made in sections of 32 tubes each, the tubes being 4 inches in diameter, 4 feet long, and supported at the ends in cast-iron tube plates. The patent joint between each tube end and the tube sheet consists of a ring of molded composition packing held in place by a cast-iron expansion ring. It is flexible enough to allow for expansion and contraction, yet absolutely prevents any gas from the furnace getting into the air. The different parts of the casing are jointed on the same plan, the composition packing being held in place by cover plates held by through bolts.

All parts are of standard sizes and are interchangeable. Consequently, the average mechanic can make the few repairs that may be needed, while the heater is in service.

While coal is the usual fuel, the Aërtube heater works well on the exhaust from gas engines, from forges, ovens, etc. Crude oil gives excellent results. Producer gas is a highly satisfactory fuel when a group of buildings is to be heated, since the gas can be piped from a central gas producer to heaters in the various buildings.

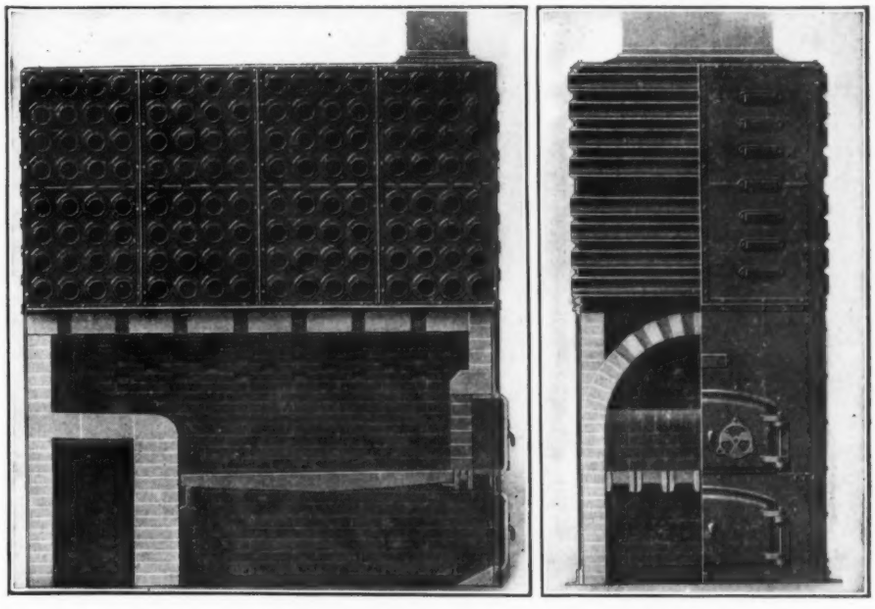
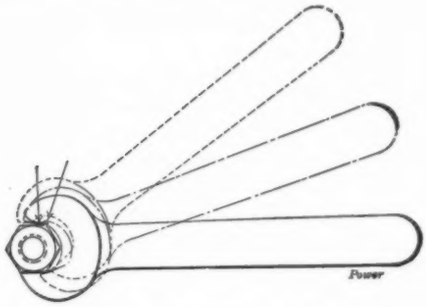


FIG. 2. SIDE AND END VIEW OF HARRISON AERTUBE HEATER

This heating system is made by the Harrison Engineering Company, New York City.

The Williams Ratchet Wrench

This wrench contains no ratchet mechanism, although it does the work of a ratchet wrench. Its action is shown in the illustration. It is made exactly like an ordinary wrench, with the exception that the useless end of one side has been cut off. This produced a tool with a reciprocating action, and without wear on either nut or tool, it is said.



POSITIONS TAKEN BY THE WILLIAMS RATCHET WRENCH

There is no lifting of the wrench from the nut as it is turned on the thread. It can be used for either right- or left-hand adjustment. In operation the jaws are simply swung back, and the short jaw rolls on the flat side of the nut, releasing the jaw on the other side. When the long jaw comes in contact with the next flat surface of the nut, the short jaw hooks the corner diametrically opposite the one in contact with the point of the long jaw. A reverse motion of the handle causes the nut to turn. This wrench is made by the J. H. Williams Company, 150 Hamilton avenue and Richards street, Brooklyn, N. Y.

Michigan N. A. S. E. State Convention

Mayor Farrel, of Kalamazoo, was at his best when he made the address of welcome at the ninth annual convention of the Michigan State National Association of Stationary Engineers association at the armory. He reviewed the progress of the work done in the past by the association and displayed a remarkable familiarity with the organization and its purposes. In speaking of the exhibit, which occupied the same hall in which the opening exercises took place, he said that he was surprised and gratified to see that the display was of such mechanical usefulness.

Senator Walter Taylor also made a witty speech in which he welcomed the delegates and announced that the engineer was a man upon whom great responsibilities rested. National Secretary Fred W. Raven, of Chicago, made the response, and dwelt upon the progress and work of the association from the date of its inception. His remarks were especially well received by the delegates.

Addresses were also made by A. C. Benton, State president; A. B. La Franier, past president; E. J. Jacques, past national president; George D. B. Van Tassel, past national president, and J. D. Clement, secretary of the Kalmazoo commercial club.

At the business session which followed, A. C. Benton made a strong talk full of good advice and suggestions for the betterment of the association. He recommended that more interest be taken in the educational work, that the license law be supported loyally by every member of the order and that delegates at State conventions should by their conscientious devotion to the purposes which bring them together, their sobriety and general behavior, create a favorable impression wherever the meetings are held and demonstrate that the stationary engineer is progressing in company with the rest of the world.

Some earnest discussion was held regarding the passing of a State license law and it seems probable that the hopes of the engineers in this regard will be realized soon.

During the past year an educational contest has been carried out by the State organization and the awarding of the prizes was an interesting part of the program. Other State associations would do well to adopt this method of stimulating interest in the affairs of the order. Fred Muryne, of Kalamazoo, was awarded the first prize; William E. Fuller, of Battle Creek, second prize; Chauncy Davis, of Kalamazoo, third prize; Fred J. Tesch, of Flint, fourth prize; and W. E. Fuller, A. E. C. Smith, of Kalamazoo, and C. C. Hale, of Pontiac, the fifth, sixth and seventh prizes respectively.

Saginaw was chosen as the next place of meeting under the condition that the organization there be revived inside of a year. Saginaw had a flourishing organization at one time but different obstacles arose and the association failed. Since that time several attempts have been made to reorganize it, and in hopes of pushing the matter a bid for the State convention was made. There is little doubt but what the efforts to revive the organization will be succussful.

Officers for the ensuing year were elected as follows:

H. F. Brandan, of Detroit, president; William E. Fuller, of Kalamazoo, vice-president; G. B. Richardson, of Pontiac, secretary; William Hayton, of Kalamazoo, treasurer; George Turnbull, of Flint, conductor, and F. T. Buch, of Lansing, doorkeeper. William Moore, of Detroit, was elected trustee for three years, and F. W. Turner, of Owasso, for two years. A. B. La Franier, of Bay City, was elected State deputy.

Firms having representatives at the convention were:

Adam Cook's Sons Company, Advance Pump and Compressor Company, American Oil Company, Anchor Packing Company, V. D. Anderson Company, Arrow Boiler Compound Company, A. M. Byers Company, Carbox Company, S. P. Conkling Company, Crandall Packing Company, Garlock Packing Company, Greene, Tweed & Co., Hawkeye Boiler Compound Company, Hills, McCanna Pump Company, Holten-Weatherwax Company, International Correspondence Schools, Jenkins Brothers, Keasby-Mattison Company, Kenneth Anderson Manufacturing Company, Keystone Lubricating Company, L. R. Klose Electric and Manufacturing Company, Lake Erie Boiler Compound Company, Lunkenheimer Company, Lyons Boiler Works, Murphy Iron Works, National Vacuum Heating Company, New Era Manufacturing Company, Ohio Blower Company, J. H. Parsons Chemical Company, William Powell Company, POWER AND THE ENGINEETR, Quaker City Rubber Company, Quinn Manufacturing Company, F. Raniville Company, J. A. Rae Company, Schaeffer & Budenberg Company, Standard Oil Company, Steam Appliance Company, Strong, Carlisle & Hammond, Under Feed Stoker Company of America, United States Graphite Company, Westinghouse Machine Company, Wheeler Blaney Company, Wickes Boiler Company, Williams Gauge Company, J. T. Wing Company and C. C. Wormer Machinery Company.

SOCIETY NOTES

The next convention of the Oil Mill Superintendents will be held at Galveston, Tex., and not at Houston, as reported in our issue of July 12.

NEW PUBLICATIONS

LAW AND BUSINESS OF ENGINEERING AND CONTRACTING. By Charles Evan Fowler. McGraw-Hill Book Company, New York. Cloth; 162 pages, 5½x9 inches. Price, $2.50 net.

In the first chapter the author discusses the relation which should exist between the consulting engineer and the contractor. The second and third chapters deal with the ordinary forms of contracts and specifications. The two succeeding chapters take up the special forms of these documents. The chapters dealing with estimating, organizing and inspecting contract work contain numerous suggestions, in the form of actual illustrations, for estimate sheets, cost cards and inspectors report blanks. The concluding chapter deals with the essentials of contract law. The requirements of a valid contract are clearly defined and the various kinds of contracts are enumerated.

The matter contained in this book is presented in a clear, concise and logical manner. The book constitutes a handy reference work and guide for consulting engineers, builders, contractors, inspectors and all others having to do with the business end of engineering and contracting.

CORROSION AND PRESERVATION OF IRON AND STEEL. By A. S. Cushman and H. A. Gardner. McGraw-Hill Publishing Company, New York. 373 pages; 6x9 inches; cloth; illustrated. Price, $4 net.

So much has been written upon the corrosion of iron and steel that there remains but little new material to be added. The present work, however, is based upon such authoritative information as has appeared in various bulletins from time to time, and is supplemented by original investigations by the authors. Moreover, the subject is dealt with in a concise and logical manner, and the addition of a complete set of illustrations serves to fix the matter more firmly in the reader's mind.

The treatment is based upon the "electrolytic theory," for the proper understanding of which chapters upon the "theory of solutions" and the "application of the electrolytic theory" have been incorporated. The inhibition of corrosion by the action of various chemical solutions is fully discussed, and it is shown that some substances supposed to prevent corrosion actually stimulate it. The proper method of applying the various protective coatings is cited, together with the results of a number of tests; the chapter upon paints being particularly instructive. A complete bibliography appended to the text adds greatly to its usefulness.

NEW INVENTIONS

Printed copies of patents are furnished by the Patent Office at 5c. each. Address the Commissioner of Patents, Washington, D. C.

PRIME MOVERS

INTERNAL COMBUSTION ENGINE. Harry Eason, New York, N. Y., assignor, by direct and mesne assignments, to Eason Engine Company, a Corporation of Pennsylvania. 963,880.

GASOLENE ENGINE. Chester Charles Jones, Beatrice, Neb. 963,898.

STEAM TURBINE. Isaac Oesterblom, New York, N. Y., assignor of one-half to Harry P. Wood, New York, N. Y. 963,927.

MOTOR WORKED BY EXPLOSIVE MIXTURE. Antoine Lavoix, Paris, France, assignor to Société Francaise de Constructions Mecaniques (Anciens Establissements Cail), Denain, France. 964,030.

ROTARY ENGINE. James W. Keating and Allan McDonald, Portland, Ore. 964,431.

BOILERS, FURNACES AND GAS PRODUCERS

BOILER. Harry S. Martin, Dunkirk, N. Y., assignor to United States Radiator Company, Dunkirk, N. Y., a Corporation of New York. 963,915.

SMOKE-CONSUMING FURNACE. John S. Smith, St. Louis, Mo. 963,953.

HYDROCARBON BURNER. Augustus C. Williams, Brookfield, Mo. 963,969.

HYDROCARBON BURNER. William Newton Best, Jr., New York, N. Y., assignor of three-fourths to William Newton Best, Sr., Brooklyn, N. Y. 963,985.

STEAM BOILER FURNACE. Herman A. Poppenhusen, Evanston, and Joseph Harrington, Riverside, Ill. 964,053.

LIQUID HYROCARBON-BURNING APPARATUS. Louis K. Leary, Los Angeles, Cal. 964,031.

CRUDE-OIL BURNER. Ernest F. Stanton, Wellington, Tex. 954,457.

POWER PLANT AUXILIARIES AND APPLIANCES

TWO-STAGE PUMP. William T. Gray, El Campo, Tex., assignor to El Campo Machine Company, a Corporation of Texas. 963,756.

AIR COMPRESSOR. Frank Heath Merrill, Plainfield, N. J., assignor, by mesne assignments, to Gas Engine Pneumatic Company, Plainfield, N. J., a Corporation of New Jersey. 963,788.

COMBINED GOVERNOR AND REGULATOR FOR AIR COMPRESSORS. John L. Osborne, Erie, Penn. 963,803.

CARBURETER. John Peterson, Chicago, Ill., assignor to Dibelka & Breska, Chicago, Ill., a Copartnership. 963,804.

GOVERNING MECHANISM FOR ELASTIC FLUID TURBINES. Frederick Samuelson, Rugby, England, assignor to General Electric Company, a Corporation of New York. 963,811.

MUFFLER FOR EXPLOSIVE ENGINES. De Wane B. Smith, Deerfield, N. Y. 963,822.

VALVE. Frank F. Varlie, Marianna, Ark. 963,836.

VALVE AND COCK. Alfred Williams, Streatham, London, England, assignor to Charles Henry Howe, London, England. 963,842.

TURBINE-CONTROLLING DEVICE. Raymond N. Ehrhart, Pittsburg, Penn., assignor to the Westinghouse Machine Company, a Corporation of Pennsylvania. 963,881.

CARBURETER. John R. Mack, New York, N. Y., assignor to John R. Locke, Brooklyn, N. Y. 963,914.

AIR PUMP. George McKerahan, Altoona, Penn. 963,923.

IGNITION APPARATUS. Arthur E. England, Boston, Mass., assignor to Arthur A. Maxwell, trustee, Worcester, Mass. 964,007.

SPARK PLUG. Irwin Floyd Kepler, Akron, Ohio. 964,028.

LUBRICATOR. Guy E. Ledgerwood, Hannibal, Mo. 964,032.

SEAM LOCK FOR TUBES. William H. McNutt, New York, N. Y., assignor, by mesne assignments to the McNutt Non-Explosive Manufacturing Company, New York, N. Y. 964,048.

BELT SHIFTER AND TIGHTENER. Hiram A. Perkins, Rochester, N. Y., assignor to American Wood Working Machinery Company, Rochester, N. Y., a Corporation of Pennsylvania. 964,051.

PIPE JOINT. August T. Pelugh, Hoboken, N. J. 964,052.

STARTING MECHANISM FOR INTERNAL COMBUSTION ENGINES. Lloyd Yost, St. Marys, Ohio. 964,138.

CARBURETER. John M. Kelley, Rochester, N. Y. 964,165.

TRIP VALVE. Adalbert W. Fischer, Philadelphia, Penn., assignor to Schutte & Koerting Manufacturing Company, Philadelphia, Penn., a Corporation of Pennsylvania. 960,872.

OIL CAN. Jacob Gullong, Holyoke, Mass. 960,898.

PIPE COUPLING. Clinton Guyer, Muncy, Penn., assignor of one-half to William C. Crawford, Muncy, Penn. 960,899.

PRESSURE GAGE ALARM. Charles D. Hill, Clifton Springs, N. Y. 960,920.

WATER GAGE. Carl Wilhelm Johnson, Brockwayville, and Charles Merridith Rathke, Pittsburg, Penn. 960,944.

STEAM, AIR AND WATER TRAP VALVE. Fred W. Leuthesser, Chicago, Ill. 960,972.

AIR PUMP FOR USE WITH CONDENSERS AND THE LIKE. Philip Francis Oddie, London, England. 961,000.

STEAM BOILER GAGE. William T. Piper, North Andover, Mass. 961,008.

STEAM SEPARATOR. Henry W. Spencer, London, England. 961,037.

VALVE MECHANISM FOR CORLISS ENGINES. Benjamin T. Allen, Harrisburg, Penn., assignor to Harrisburg Foundry and Machine Works, Harrisburg, Penn., a Corporation of Pennsylvania. 964,194.

PIPE COUPLING. William H. Goss, Stonington, Me. 964,238.

VALVE AND VALVE ACTUATING ARRANGEMENT FOR INTERNAL COMBUSTION ENGINES. Samuel Isaac Parker, Teddington, England. 964,308.

GAGE COCK. John Stockwell, Marine City, Mich. 964,329.

CARBURETER. James Clendenin Eckert, Stamford, Conn., administrator of Charles Fox, deceased. 964,409.

HEATER FOR CARBURETERS. James Clendenin Eckert, Stamford, Conn., administrator of Charles Fox, deceased. 964,410.

LUBRICATOR. Albert J. Oaks, South Park, Penn. 964,450.

VALVE. Samuel M. Guss, Reading, Penn., assignor of one-half to Herbert S. Guss, Reading, Penn.; Florence E. Guss, administratrix of said Samuel M. Guss, deceased. 964,468.

ELECTRICAL INVENTIONS AND APPLIANCES

ELECTRIC ARC LAMP. Thomas Edgar Adams, Cleveland, Ohio, assignor to the Adams-Bagnall Electric Company, Cleveland, Ohio. 963,736.

ELECTRIC THERMOSTAT. Fred W. Harris, Wilkinsburg, Penn., assignor to Westinghouse Electric and Manufacturing Company, a Corporation of Pennsylvania. 963,763.

GALVANIC BATTERY. Stephan Benko, Budapest, Austria-Hungary, assignor to Company Limited for Exploitation of Inventions by Stephan Benko, Budapest, Austria-Hungary. 963,852.

ELECTRIC SWITCH. John L. Creveling, New York, N. Y., assignor to Safety Car Heating and Lighting Company, a Corporation of New Jersey. 963,996.

ELECTRICITY-MEASURING INSTRUMENT. Johannes Gorner, Eschersheim, near Frankfort-on-the-Main, Germany, assignor to the firm of Hartmann & Braun Aktiengesellschaft, Bockenheim, Frankfort-on-the-Main, Germany. 964,015.

CURRENT INTERRUPTING DEVICE. Oscar M. Leich, Genoa, Ill., assignor to Cracraft-Leich Electric Company, Genoa, Ill. 964,169.

PORTABLE ELECTRICAL TOOL. Frank J. Backscheider, Cincinnati, Ohio. 964,197.

POWER PLANT TOOLS

PIPE COUPLING. Frederick W. Reed, Trafford, Penn. 964,315.

ROTARY FIELD MAGNET. Emil Volkers, Berlin, Germany. 964,343.

PIPE TONGS. George A. Lane, Florence, Cal., assignor of one-half to Edward C. Kellermeyer, Taft, Cal. 963,903.

ATTACHMENT FOR MONKEY WRENCHES. Frank Fisher, Reardan, Wash. 964,010.

WRENCH. Andrew S. Steen, Adams, N. D. 964,067.

WRENCH. James G. Portteus, Marion, Ind., assignor of one-half to Theodore Portteus, Indianapolis, Ind. 964,313.

WRENCH. George H. Watson, Marshall, Mich. 964,346.

LIFTING JACK. Erastus L. Coddington, Vanburen, Ind., assignor of one-half to Charles M. Stuart, Marion, Ind. 964,394.

ENGINEERING SOCIETIES

AMERICAN SOCIETY OF MECHANICAL ENGINEERS

Pres., George Westinghouse; sec., Calvin W. Rice, Engineering Societies building, 29 West 39th St., New York. Monthly meetings in New York City.

NATIONAL ELECTRIC LIGHT ASSOCIATION

Pres., W. W. Freeman, Brooklyn, N. Y.; sec., T. C. Martin, 33 West Thirty-ninth St., New York.

AMERICAN SOCIETY OF NAVAL ENGINEERS

Pres., Engineer-in-Chief Hutch I. Cone, U .S. N.; sec. and treas., Lieutenant Henry C. Dinger, U. S. N., Bureau of Steam Engineering, Navy Department, Washington, D. C.

AMERICAN BOILER MANUFACTURERS' ASSOCIATION

Pres., E. D. Meier, 11 Broadway, New York; sec., J. D. Farasey, cor. 37th St. and Erie Railway, Cleveland, O.

WESTERN SOCIETY OF ENGINEERS

Pres., J. W. Alvord; sec., J. H. Warder, 1735 Monadnock Block, Chicago, Ill.

ENGINEERS' SOCIETY OF WESTERN PENNSYLVANIA

Pres., E. K. Morse; sec., E. K. Hiles, Oliver building, Pittsburg, Penn. Meetings 1st and 3d Tuesdays.

AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS

Pres., L. B. Stillwell; sec., Ralph W. Pope, 33 W. Thirty-ninth St., New York. Meetings monthly, excepting July and August.

AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS.

Pres., Prof. J. D. Hoffman; sec., William M. Mackay, P. O. Box 1818, New York City.

NATIONAL ASSOCIATION OF STATIONARY ENGINEERS

Pres., William J. Reynolds, Hoboken, N. J.; sec., F. W. Raven, 325 Dearborn street, Chicago, Ill. Next convention, Rochester, N. Y., September 12-17, 1910.

UNIVERSAL CRAFTSMEN COUNCIL OF ENGINEERS

Grand Worthy Chief, W. S. Cadwell, Chicago, Ill.; sec., Thomas H. Jones, 244 Eighth street, N. E., Washington, D. C. Next convention, Buffalo, N. Y., August 2-5, 1910.

AMERICAN ORDER OF STEAM ENGINEERS

Supr. Chief Engr., Frederick Markoe, Philadelphia, Pa.; Supr. Cor. Engr., William S. Wetzler, 753 N. Forty-fourth St., Philadelphia, Pa. Next meeting at Philadelphia, June, 1911.

NATIONAL MARINE ENGINEERS BENEFICIAL ASSOCIATIONS.

Pres., William F. Yates, New York, N. Y.; sec., George A. Grubb, 1040 Dakin street, Chicago, Ill. Next meeting, St. Louis, Mo., January 16-21, 1911.

OHIO SOCIETY OF MECHANICAL ELECTRICAL AND STEAM ENGINEERS

Pres., O. F. Rabbe; sec. and treas., Prof. F. E. Sanborn, Ohio State University, Columbus, Ohio.

INTERNATIONAL MASTER BOILER MAKERS' ASSOCIATION

Pres., A. N. Lucas; sec., Harry D. Vaught, 95 Liberty street, New York. Next meeting at Omaha, Neb., May, 1911.

INTERNATIONAL UNION OF STEAM ENGINEERS

Pres., Matt. Comerford; sec., Robert A. McKee, 606 Main St., Peoria, Ill. Next convention, Denver, Colo., September, 1910.

NATIONAL DISTRICT HEATING ASSOCIATION.

Pres., G. W. Wright, Baltimore, Md.; sec. and treas., D. L. Gaskill, Greenville, O.

Moments with the Ad. Editor

A department for subscribers edited by the advertising service department of Power and the Engineer.

The Senate Committee has gone and done it!

It has investigated and reported on the reasons for the "increased cost of living"—

And it has decided that one reason is *Advertising!*

We suppose their line of argument (if they had one) was that if John Jones makes shoes and spends $1000 advertising them, he must charge enough more for his footwear to get back that $1000.

Which is perfectly true—*but* the worthy Senators who make our laws luckily do *not* make our shoes.

If they did perhaps they would know that there are two distinct items of cost to be met before the consumer gets his boots.

One of these is the cost of manufacture—the other the cost of distribution—

And *advertising* is the cheapest distributor yet discovered.

Therefore, if John Jones had not disposed of his shoes by spending $1000 in advertising them, he would have had to spend much more on other methods of distribution.

This would seem to prove that John Jones is a better business man than are the members of the Senate Committee.

In these days of keen competition is it reasonable to suppose that the business department of any manufacturing concern would use any but the cheapest possible method of distributing its product?

Advertising has reduced the cost of getting goods from the manufacturer to the consumer—and more—

It has made possible a *lower cost of manufacture* because it creates a demand for the goods, which means a larger production, which in turn means a lower cost because the more goods a man makes the cheaper he can make them.

Thus with Advertising *reducing* the cost of *distribution*, as well as the cost of *manufacture*, it is hard to see how even a Senate Committee could lay part of the "increased cost of living" at the door of Advertising.

We fear the Senators have followed about the same line of reasoning as the school boy who said, "Light comes from the sun—feathers are light—therefore feathers come from the sun."

The point is, Advertising has become a great force in modern commerce.

It has kept the cost of manufactured goods lower than it could possibly have been otherwise.

It educates buyers to spend their money wisely and guarantees that the consumer will get what he pays for.

The advertising pages of the world's periodicals are now and ever shall be the great, universal marketplace, where the "ultimate consumer" knows he will get a square deal.

Because Advertising is one of the newer sciences, only a comparatively few experts have known what it is all about. The average layman has considered it simply an expense.

But now it has become a recognized, necessary part of every manufacturing business—the *most* important part of any selling system—

Simply because it has proved to be the best and cheapest method of selling—the Senate Committee to the contrary notwithstanding.